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NOTES AND COMMENTS.

Judging Temperatures.

Much as pyrometric measurement of temperatures has developed of late years, there is still often great difficulty in applying pyrometers under works conditions and in everyday practice in such places as general foundries. Consequently many workers, even for the annealing of malleable cast iron, prefer to be guided by optical inspection of the metal; and it must be admitted that the results frequently appear to justify the preference. The following table (from Pouillet) may be taken as a general guide for the relation between appearance and temperatures :—

	Deg. C.	Deg. F.
First visible red	525	977
Dull red heat	700	1,292
Turning to cherry	800	1,472
Actual cherry red	900	1,652
Bright cherry red	1,000	1,832
Dull orange	1,100	2,021
Bright orange	1,200	2,192
White heat	1,300	2,372
Bright white heat	1,400	2,552
Dazzling white heat	1,500	2,732

At the same time it must be remembered that variations of as much as 100 deg. C. or more occur in readings judged by colour appearance. The reading depends upon the person and also on the surroundings. In bright light a colour will not be as intense as in the dark, and when judging heats or temperature by the colour, the conditions of lighting should always be the same, otherwise a considerable variation in the estimation is inevitable. A strong light on molten metal at the right pouring temperature will cause it to appear at a much lower temperature than when viewed in the shade or a dull light. Nevertheless, when conditions are fairly constant (and the dinginess of some foundries appears to be never relieved) it is surprising how regular the estimations of temperatures can be.

In tempering and hardening tools, also, it is common practice to rely on colour appearance, the following relations being generally accepted :—

	Deg. C.
Light straw	220 to 230
Dark straw	240
Yellowish brown	255
Reddish brown	265
Purple	275
Violet	285
Cornflower blue	295
Pale blue	310 to 315
Sea-green or grey	330

Here, again, the colour may be misleading, for it results from oxidation of the surface of the metal and the change is thus affected by both time and temperature. Brearley quotes experiments which showed that straw colour could be obtained at temperatures ranging from 200 deg. C. to 275 deg. C., the time involved ranging from 6 minutes for the low temperature to ¼ minute for the high tempera-

ture. To obtain a brown colour at 200 deg. C. a period of 49 minutes was required, only three minutes being necessary at 275 deg. C. It will thus be clearly seen that the rate of cooling as well as the actual temperature of the tool influences the colour, and therefore the colour test is at the best an empirical guide. However, when the conditions of working are not varied seriously considerable value can be attached to the colour test.

Chemistry Aid and the Brass Foundry.

Founders who have gone through life without calling to their aid the services of the analyst, metallurgist or foundry consultant, are inclined to cast serious doubts on the help which the chemist is claimed to render at times. The man who produces only such castings as those which have to meet no special requirements, or who is content to see first-class work given to other concerns, probably has really no use for the chemist; for the latter might insist on such radical reforms in working practice as to disconcert his client. But where the founder's aim is the production of good work and the avoidance of waste, expert advice and chemical analysis may be regarded as essential, or at least highly profitable.

The adoption of a new and admittedly more efficient system of melting has often caused trouble and the system, on that account, abandoned, whereas the services of a chemist might have ascertained the nature and cause of the trouble and put the process on a sound footing. Such cases have occurred in attempting to adopt fuel-oil furnaces, particularly when the flame has come into contact with the metal, or when the loss of zinc by volatilisation (perhaps through greater heat) has increased and not been determined. The control of the mixtures by analysis, too, often saves considerable sums and avoids the use of excessive amounts of expensive constituents. This is perhaps the greatest field of usefulness for the chemist, though his advice on the prevention of defective work is also amply repaid by the resultant saving.

Then, again, he can render distinct aid and secure considerable economy in expenditure by examining and analysing materials other than the metals. These materials include various refractories (fire brick, fire clay, fire sand and carborundum); moulding and core sands, which should be tested for fineness, binding qualities, resistance to hot metal, porosity, etc.; crucibles, which should be tested regularly to ensure maintaining uniform quality; coke, in which the ash and sulphur should be determined, apart from the practical test for burning qualities; fuel-oil, which should receive similar attention; and others. Copper-bearing refuse of various kinds should be examined for its value, and then, if it cannot be worked up in the foundry, it can be sold on the basis of its metallic contents.

There is, of course, the important matter of experimental work, which is generally conducted on very doubtful and empirical lines. Such work often cannot be satisfactorily undertaken by the foreman, as the nature of his duties prevents him from giving concentrated attention to any problem for any great length of time. The chemist, however, can very well attend to this kind of work. He should also record the results of all tests made, whether they are chemical, physical, or practical tests of material. To fill all his possible functions, naturally, the chemist should be permanently on the staff; but where the size of the foundry does not justify the expense, the services of the consulting chemist called in at regular times or when required are many times repaid by results.

The Proposed Ministry of Science.

The suggestions to the effect that the Government should take steps to create a Ministry of Science is one with the main principles of which it is not at all difficult to agree. What is meant by those who are at present discussing the subject, is that certain definite measures should be adopted with a view to increasing the volume of scientific knowledge in this country, and laying such knowledge as we have already under more generous and continuous contribution to the sum of industrial and, therefore, national prosperity. It is, perhaps, so long as these objects can be kept in view and attained, not a matter of primary importance whether a distinct Ministry be created, or the functions of such a Ministry be grafted on some Department, such, for example, as the projected Ministry of Commerce, provided that it is not lost amongst a multitude of small departments. Now that we have arrived at a stage at which by common consent the creation of a Ministry of Commerce cannot be longer deferred without serious peril to national interests, it is well that stress should be laid upon the necessity of such a Ministry concerning itself in the widest manner with the intimate connection between science and commerce.

Amongst others, Sir Robert Hadfield has pressed in a convincing manner for the creation of a Ministry of Science. Various suggestions have also been made by Prof. F. G. Donnan, F.R.S., of University College, London. Prof. Donnan supports the idea of a separate Ministry, and outlines its functions at some length. He proposes, *inter alia*, that it should establish national laboratories and "bureaus" for the purpose of undertaking extensive investigations concerning the advancement of scientific methods of control, standardisation and testing of materials, and dealing with the application of scientific knowledge to every phase of national life. A Ministry of Science would also guide the domestic and foreign policy of the Cabinet by having ready at a moment's notice complete and detailed information concerning every question relating to science, whether pure or applied, and by being in a position to know where and to whom to apply for special advice and information. It would foster, endow and promote the teaching and investigation of science by giving much larger grants of money to the scientific laboratories. It would promote scientific manufacture and production by giving grants towards the establishment of new and existing industries. It would establish, endow and develop Higher Schools of Commercial Science, whether at Universities or elsewhere. It would also establish and endow first-class trade schools for the training of skilled manual workers. It would, beyond all this, provide schools for the scientific training of journalists, "so that there shall be produced men who are able to understand, follow and continuously present the results of scientific inquiry and scientific technical development to the readers of the daily Press." These are a few of the outstanding features of Prof. Donnan's programme—by no means all. It will be seen from them that the programme is a large one, but then so also is the subject, as so also are the needs of the times. There is much of the work to which Prof. Donnan refers that can be done by existing institutions, such as the National Physical Laboratory, the Geological Survey, the Government Laboratories at Woolwich and elsewhere.

Works of Victoria Brass Foundry Company, Limited.

The Victoria Brass Foundry Company, Limited, is the modern development of a business established for the manufacture of light brass castings by Messrs. Young & Buchanan rather more than a century ago. Some 50 years later the business was taken over by Messrs. James Buchanan & Company, who in a small works in Leith Walk, Edinburgh, continued to trade pretty much upon the old lines, but with the addition of making a speciality of brass shells and liners for paper-making machines. The Victoria Brass Foundry Company, Limited, was incorporated in 1911 to take over the business as a going concern, and, with a view to meeting a demand for larger castings, and to allow of developments in other directions, the company transferred their business to their present premises in Bonnington Road, Leith, about 1½ miles from the centre of Edinburgh and served by a siding of the North British Railway. It was, however, not until 1915, when the general management of the company was vested in Mr. R. W. Thompson, that really serious developments were undertaken, as prior to that date the annual output of castings was only some 200 tons. Under the superintendence of Mr. Thompson the foundry has been entirely remodelled and new plant laid down, so that the present output is approximately 1,000 tons per annum and the company are able to produce castings up to 7 tons in weight in brass, gunmetal, or special alloys. Until recently they confined themselves to the production of castings, but a machine shop has now been added where they are able to finish complete the largest castings made. Further new features introduced by Mr. Thompson are the mechanical and electrical departments. In the former repairs are carried out on all kinds of machinery, whilst the electrical department is devoted to details connected with power installations at collieries, factories, shipyards, public works, etc. There is also an electrical repair shop where armatures, field coils, stators, rotors, switchgear, etc., can be repaired and rewound if necessary. A speciality is also being made in the repair of coal-cutters, etc., and in this connection a long-felt local want is being met.

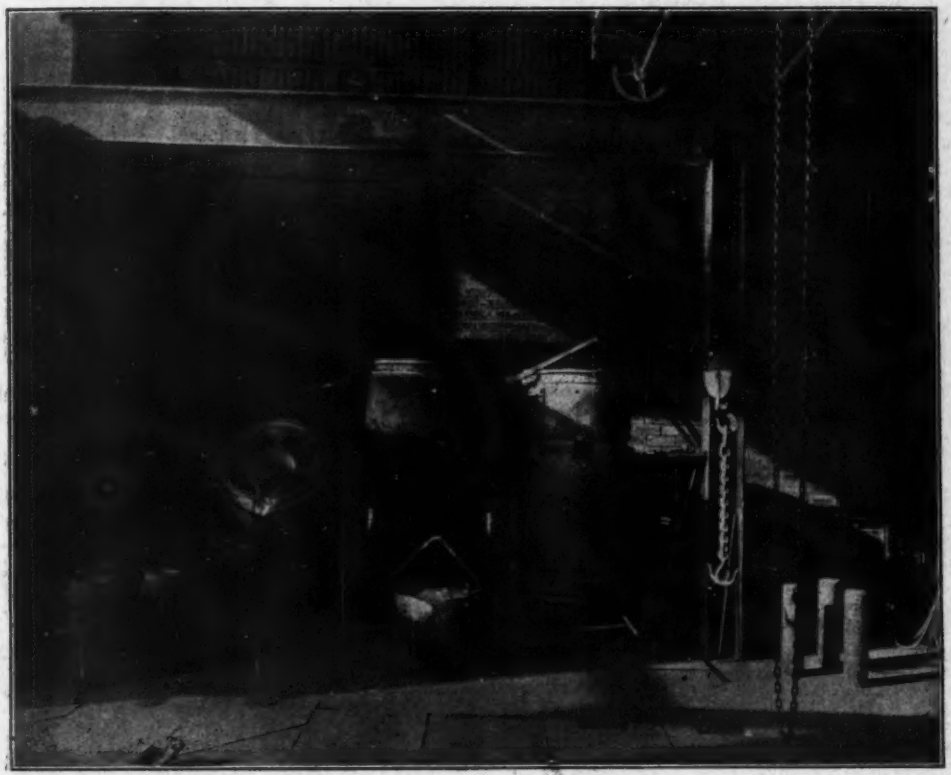


FIG. 1.—BILLET DEPARTMENT: 600-LB. TILTING FURNACES.

The foundry is covered by one span 200 ft. long by 45 ft. wide by 36 ft. high, and is particularly well lighted and well ventilated. The floor is served by a 25-ton crane. The foundry equipment comprises nine pit fires worked under natural draft, equal to a melting capacity of one ton; two M.R.V. tilting furnaces, each of 400 lbs., each with its own electrically-driven blower for the supply of forced draft, and a 7-ton reverberatory furnace which was designed and erected by the company. Together with the core stoves—of which there are

three, two large and one small, giving a combined capacity of about 6,000 cubic feet, the large stoves being served by travelling carriages—the pit fires and furnaces are ranged along one side of the foundry, thus permitting the floor to be used to the best advantage, whilst access to the machine shop is from the opposite side of the foundry. In an end gallery of the foundry, which is served by a 3-ton crane, are two 600-lb. Morgan tilting furnaces (see Fig. 1), each served by an independent electrically-driven blower. These furnaces are mainly devoted to billet-casting, copper-smelting and the like.

The machine shop, which is covered by a bay similar to that of the foundry, is provided with the usual complement of planers, lathes, slotting and drilling machines, the heavy machines being separately driven from motors and the light machines group-driven. There is also installed an Alex. Wilson compressor which supplies power for the tools and hammers used in the foundry and machine shop, and a Riehle machine (30 tons) for tensile compression and bending tests (see Fig. 2).

The work done is of a varied nature, comprising dry-sand, green-sand, loam and stucco moulding. The castings produced vary in weight from a few ounces to several tons. Amongst other work passing through the shops at the time of our representative's visit, mention may be made of shaft-liners, pump-liners, centrifugal pump casings, impellers, circulating pumps, paper machine rolls, bevel and worm wheels, flooding valves, gate valves, engine and boiler mountings, many of these being made of special alloys and to meet standard specifications and tests.

Electrical Conductivity of Materials.

The following table, after Gore, gives a variety of materials in the order of their resistance to electrical current, ebonite having the highest resistance, *i.e.*, the lowest conductivity :—

1. Ebonite.
2. Shellac.
3. Pure rubber.
4. Gutta-percha.
5. Amber.
6. Rosin.
7. Sulphur.
8. Wax.
9. Agate.
10. Glass.
11. Gems.
12. Silk.
13. Wool.
14. Hair.
15. Feathers.
16. Dry paper.
17. Leather.
18. Porcelain.
19. Camphor.
20. Chalk.
21. Lime.
22. Dry gases.
23. Dry steam.
24. Phosphorus.
25. Fatty oils.
26. Metallic oxides.
27. Ice.
28. Straw.
29. Paper.
30. Marble.
31. Dry wood.
32. Alcohol or ether.
33. Rain-water.
34. Spring-water.
35. Sea-water.
36. Graphite.
37. Brittle metals.
38. Ductile metals.

The actual difference between the conductivity of a metal and a non-metallic substance may be appreciated by the fact that if the resistance of silver be taken as 1, that of gutta-percha would be 850,000,000,000,000,000,000. No substance known can be claimed to be an *absolute* non-conductor of electricity.

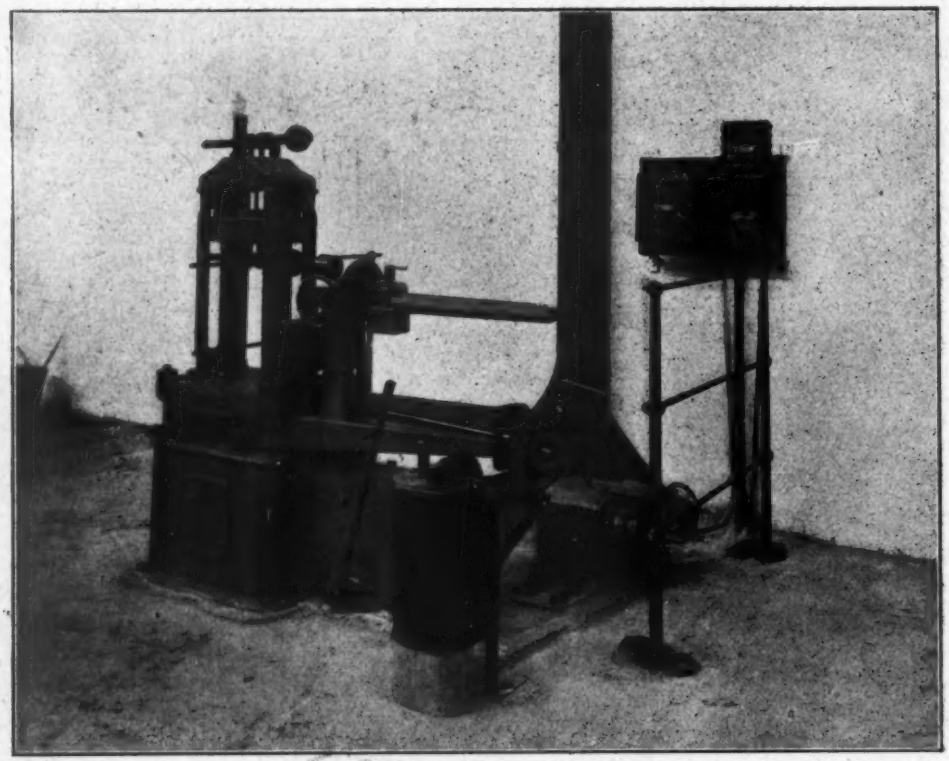


Fig. 2.—Riehle Testing Machine.

Manufacture and Uses of Alloy Steels.

The following are extracts from a report by Henry D. Hibbard issued by the United States Bureau of Mines:—

Probably the first useful alloy steel was Mushet's self-hardening tungsten tool steel, patented in 1868. Fifteen years later chromium steel, really containing chromium, was struggling for recognition for some purposes, the chief of which was for the manufacture of solid shot for piercing armour. In both of these steels the effect of the alloying element as used was in a way proportional to the amount contained. In 1882 Hadfield made his epoch-making discovery of manganese steel, and demonstrated that in iron metallurgy it is not safe to take for granted anything as to the properties of an alloy of iron with other elements, basing one's opinion on past experience and knowledge, and that the effect of an alloying element may not be proportional to its content. The development of useful nickel steels followed in a few years, and the field thus opened has since then been worked by many able and zealous men, with results of great importance and value.

Useful Alloy Steels.

The following deals exclusively with alloy steels, in which the alloying element or elements modify directly, positively, and usefully some of the properties of the products.

The eight alloy steels named below in the chronological order of their introduction are considered to meet this requirement:—

(1) Simple tungsten steels.
(2) Simple chromium steels.
(3) Manganese steel.
(4) Simple nickel steels.
(5) Nickel-chromium steels.
(6) Silicon steels.
(7) High-speed tool steels.
(8) Chromium-vanadium steels.

The first four and the sixth of these are ternary steels, the fifth and eighth are quaternary, and the seventh is of complex composition. Some of these steels may be treated while molten by the addition of a purifying or solidifying element or elements in such a small quantity as not greatly to affect the final properties. Thus a small amount of titanium, aluminium, or vanadium may be added to a chromium or nickel steel and hardly appear in the final analysis. Such a result is seen in the alloy-treated steels.

Alloy-Treated Steels.

Alloy-treated steels need be only briefly alluded to here. The method of manufacturing all steels made by the oxidation processes involves the presence in suspension or solution of harmful amounts of oxygen or oxides, and before the metal is cast means must be taken to lessen the oxygen or oxide content to or below an allowable maximum. One or more of certain elements having at steel-melting temperatures a stronger affinity for oxygen than iron has, are added to the molten metal. The oxygen leaves the iron to seize such added elements, forming new products insoluble in the iron, which in time are precipitated, gather together, and leave the metal.

Such unfinished steel also contains in solution a quantity of gases which require to be decomposed or kept in solution, for, if not, when the steel is solidifying, part of the gases will leave it and part will be imprisoned in the metal and form gas holes, of the variety commonly called blowholes. The addition of certain elements to the metal tends to prevent the separation of the gases.

Further there is a tendency of certain of the ingredients of steel to collect or segregate in an injurious way in the upper central part of a large ingot or casting, but the addition of certain elements lessens this tendency.

Elements that are added to prevent, minimise, or cure these ills are manganese, which is the most important, silicon, aluminium, titanium, vanadium, and others of less importance. The effects aimed at are therapeutic, and, though real and valuable, are mostly negative rather than positive; that is, effort is made to cause the steel to be free from some or all of the defects cited.

The proportions of these elements added are, generally speaking, only enough to cure the defects to be removed or counteracted, with a suitable excess to reasonably assure such a result in view of the uncertainties and irregularities of steel making. The excess of any of the elements named has indeed some effect on the final properties of the steel, but not enough to put the product in the class of the alloy steels. Steels so treated are considered as alloy-treated steels, they being simple steels, outside the subject of this paper, as the alloying elements do not give new or modified properties of important commercial value.

Some alloying elements are added to simple steel in such proportions as to produce only a curative effect, and the product cannot definitely be classified as a simple or an alloy-steel, as can be done when a rather large excess of the element is added. The elements vanadium and silicon are examples, both being added to cure ills in the steel, and an excess of either causes the physical properties of the steel to vary to some extent. Both are used also in undoubted alloy steels that have unique properties, which would not be anticipated from the observation of the effect of a moderate excess of either in a simple steel.

Uses of Alloy Steels.

With few exceptions all alloy steels are heat treated for use, the treatment developing in them the high physical properties they are capable of possessing. No general law regarding the effects of heat treatment of alloy steels can be laid down. Some steels when quenched from a high heat are hardened and others are softened, the latter being generally those with the higher contents of certain of the alloying elements. In respect to the effects of heat treatment, each steel is considered by itself.

Steel used for structural purposes is taken to include that used for the stationary as well as the moving parts of structures and machines, including bridges, buildings, vehicles, machine tools (except the cutting tools), armour plate, ships, uses involving resistance to abrasion or corrosion, and wire, except electrical wire, and in general all steel not used in the other two fields.

Steel used for cutting purposes includes that employed to form an actual cutting edge and that used in projectiles for war.

Steel for electrical purposes is used in magnets, core steel, non-magnetic articles, and electrical-resistance devices.

No steel suitable in a commercial sense for two of these purposes is made, though some steels

might be used for more than one purpose if a better kind for the other specific purpose were not known; thus a fair tool steel might be made of some of the harder structural steels, and a fair magnet might be made of some of the tool steels.

The effects of the alloying elements in alloy steels are various; thus nickel increases the elastic limit as compared to tensility; chromium increases the hardness of quenched steel; and manganese destroys magnetic susceptibility—effects all of which are valuable for certain purposes.

Manufacture of Alloy Steel.

Alloy steels are made by any of the steel-making processes, that is, by any of the variations of the pneumatic processes, by the acid or basic open hearth, by the electric furnace, and by the crucible. For each of the various purposes, however, the practice is more limited, the general rule being, of course, that the cheapest process is employed that will yield a product satisfactory for the purpose in view.

All alloy-steel ingots or castings should be made sound and with full tendency to pipe. Soundness, which means freedom from gas holes, is, generally speaking, a necessary requirement in order that the product may be sound, as almost any of the alloying elements interferes with or prevents the welding of steel that contains that element so that any contained gas holes in the ingots will not be welded up by hot working. Therefore they may, if near the surface, be opened to the air by scaling in heating or by forging and rolling and then be oxidised within and form seams. Chromium and nickel more than other alloying metals prevent welding in steel.

Pipe in the ingot may be shortened in length by casting the ingot with the larger end up, or it may be avoided if the ingot when so cast is squeezed laterally, or if the top is maintained in the molten state until the remainder of the ingot is solid. If neither of these means is employed enough of the top of the ingot must be discarded to get rid of any objectionable pipe. Whether any pipe is permissible depends on the use to be made of the steel.

Structural Alloy Steels.

Structural steels have some attributes in common, which makes it worth while to consider them collectively to a certain extent. These steels are working great improvements in the production of structures for various purposes, especially where the saving of weight or increase of strength or both are important, the most conspicuous example being undoubtedly the motor-car industry. Heat-treated alloy steels with double or treble the strength of the simple steels they replace and with as great or greater reliability are now in regular and most advantageous use. In common with other alloy steels, structural alloy steels owe a part of their superior properties to the presence of the alloying element, but usually far more to heat treatment when it can be given to them. In motor cars the use of alloy steels is generally not advised unless the steels are heat treated, as the gain from their use in the natural or untreated state does not compensate for the increased cost.

Most structural alloy steels are therefore used in the heat-treated condition, when the articles made of them are not too bulky or massive. Large pieces like nickel-steel rails and nickel-steel members of bridges are used without heat treatment, the advantages of increased strength and ductility that the metal possesses being due solely to the presence of the alloying element.

The difficulties attending the heat treatment of large steel parts that are bulky for their weight are holding back their general introduction. They require, as nearly as is practicable, to be uniformly heated, uniformly cooled in quenching, and afterwards, when cold, to be made true to form, as the quenching operation, however carefully done, usually leaves them warped or twisted. No doubt, in time, means will be found to overcome these drawbacks, and such pieces as rails and bridge members of alloy steels will be used regularly in the heat-treated condition. A compact object like an armour plate, though very large, may be quenched without unmanageable warping because of its simple shape. The difficulty in making straight and true such an article as a heat-treated rail of pearlitic alloy steels lies largely in the springiness of the treated metal. It is not easy to give it the correct amount of set needed to counteract or obliterate a crook, bend, or twist that may result from quenching. Yet this is necessary when the piece must be straight or true to shape. Stretching slightly beyond the elastic limit as is done to some thin steel sheets and relatively small bars to straighten them might be efficacious, but is not to be easily done with a piece of such irregular cross section as a rail.

The effects of heat treatment are so great that a certain steel may be given a very wide range of properties, depending on the treatment, and any desired set of properties within that range may be obtained solely by varying the heat treatment. The principal variant is the degree of the second heating. The lower this is the stronger and stiffer the steel, and the higher the weaker and more ductile it is.

This effect of heat treatment on steel is illustrated by figures showing the results of 40 tensile tests made from one heat of steel, each test piece having had a different heat treatment. Five, which cover the range, are given in the table below:—

Results of tensile-strength tests of 5 pieces of steel each receiving a different heat treatment.

Tensile Strength.	Elastic limit.	Elastic ratio.	Elongation in 2 inches.	Contraction of area.
Lbs.	Lbs.	Per cent.	Per cent.	Per cent.
84,850	50,500	60	28	67.5
120,975	90,000	74.5	14.5	51
166,950	157,500	94	12.5	44
205,600	200,000	97	13	48.7
240,975	225,000	93	9	20.5

Analysis of the original steel showed C, 0.25; Mn, 0.50; Cr, 1.07; and V, 0.17 per cent., but similar results could be obtained with a variety of compositions.

For making small parts that must be true and well finished the structural alloy steels are generally heat treated before they are machined, and this requirement prevents the use in such parts of steel of the highest strength attainable because steel having that strength is not commercially machinable. Generally speaking, any part that is to have an elastic limit of more than 100,000 lbs. per sq. in. must be treated after having been machined, not before, because most steels having a higher elastic limit than that are too hard to allow machining by commercial processes, though chromium-vanadium steels with an elastic limit of 150,000 lbs. per sq. in. are claimed to be machinable, that is, they may be cut with high-speed steels at a profitable rate. An elastic limit of

100,000 lbs. or more per sq. in. can be imparted to steel only by heat treatment, as no untreated steel of a commercial grade will have so high a limit. The tables of properties given later show how much more the properties possessed are imparted by treatment than by composition.

The size or massiveness of the article has a great effect on the results obtained by any given heat treatment. The greater the mass the lower the qualities, though not in exact proportion. Thus the mass must always be considered in connection with the properties desired, and the composition and heat treatment prescribed must be modified accordingly, though even then the effect of mass may be only partly compensated for.

The modulus of elasticity of many, if not all, structural alloy steels in common with other steels is not changed much by heat treatment or variations in composition, and is usually between 28,000,000 and 30,000,000 lbs. per sq. in.; that is, the modulus of the steel in its annealed, hardened and tempered condition remains practically unchanged. The following table was compiled from data given by Landau:—

Moduli of elasticity of some Alloy Steels.

Composition of steel.								Modulus.
C.	Si.	Mn.	P.	S.	Cr.	Ni.	V.	
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
0.50	0.13	0.82	0.01	0.02	1.25	—	0.14	29,240,000
0.47	1.83	0.70	0.01	0.01	—	—	—	28,950,000
0.48	0.16	0.44	0.01	0.01	0.98	2.02	—	28,840,000
0.30	0.19	0.64	0.01	0.01	—	3.25	0.18	28,260,000
0.25	0.21	0.74	0.01	0.01	—	3.55	—	28,170,000
0.24	0.21	0.46	0.01	0.02	0.96	2.02	—	28,200,000
0.25	0 16	0.50	0.01	—	1.05	—	0.16	30,158,000

Because of the unchangeability of the modulus of elasticity the stiffness or rigidity of steel within the elastic limit is not changed either by heat treatment or the presence of any of the alloying elements, except perhaps manganese in manganese steel and nickel in high-nickel steels. Heat treatment does increase the elasticity, however, so that a piece of heat-treated steel may return to its original form after having endured a stress that would have permanently deformed it in its untreated condition; that is, it is given some of the springiness of heat-treated springs.

Many of the structural steels, particularly those used in motor-car manufacture, have a great endurance against fatigue when subjected to repeated alternating stresses. The heat treatment increases their durability in this test even more noticeably than it does the properties determined by the tensile test.

Simple Tungsten Steel.

Mushet's air-hardening steel, the first of the alloy steels, may be considered as a simple tungsten steel, though it contained so much manganese (about 2 per cent.) that it might with some reason be classed as a quarternary steel, as it contained also about 2 per cent. of carbon and 6 per cent. of tungsten. The manganese was essential to give the self-hardening property. The steel is now becoming obsolete, having had a useful career and having formed an indispensable link in the development of the high-speed tool steels discussed later.

Tungsten is very heavy, its specific gravity being, according to recent determinations, about 19.3, and it is the most infusible substance known except carbon and, perhaps, boron. These properties have some effect on the production of tungsten steel.

Tungsten steel is generally, if not always, made by the crucible process. The pots are charged cold by packing in the materials, the tungsten being placed at the top to counteract in a measure its tendency to settle because of its high specific gravity. If this tendency operated unchecked there might be at the bottom of the pot a rather infusible mush of high-tungsten alloy which would not pour out, and if it did the ingot would have an irregular composition because of the uneven distribution of the tungsten. The steel is melted and then "killed" in the crucibles by holding them in the furnace for 30 or 40 minutes after the charge has melted, until the steel ceases to bubble or work, and lies dead in the pot. The pots are sometimes cast singly or doubly by hand pouring or collectively by means of a ladle into which all the pots of a furnace charge are emptied. Good tungsten steel makes remarkably sound solid ingots, except for the pipe, though tungsten itself is not considered to aid in removing or controlling either the oxides or the gases. It is added solely for its effect on the finished and treated steel. This lack of power of tungsten to deal with oxides and gases arises no doubt from its low calorific power, its heat of combustion being given (with qualification) as about 1,000 calories, whereas iron burned to Fe_3O_4 gives 1,612 calories.

Simple tungsten steels of commercial grades are heated, forged, and rolled in much the same manner as other high-carbon steels, presenting no special problems or difficulties. They are at present chiefly used in permanent magnets for electric meters, in small dynamos, and hand use, for which it has been used for 30 or 40 years. The steel contains about 0.6 per cent. of carbon and 6 per cent. of tungsten. Some has been made in recent years containing 0.2 to 0.3 per cent. of vanadium, chromium, or molybdenum which were considered at the time to give greater retentivity to the steel, but those ingredients are now generally held to be of no practical value, adding nothing to the fitness of the steel for its purpose.

Some buyers of magnet steel do not specify composition, but only performance, that is, what magnetic properties the steel must have. To make permanent magnets retain their magnetism as much as possible they are made very hard by heating and quenching. They are then magnetised, and if they are to be used for electric meters they are seasoned by a treatment involving protracted heating to 100 deg. C. (212 deg. F.) to make their magnetism as nearly constant as possible.

A variety of tungsten steel containing about 1 per cent. of carbon and 3 to 4 per cent. of tungsten is made and used as a tool steel for taking finishing cuts on iron and steel in the machine shop. It acts more like a simple steel than a self-hardening steel, as it requires to be hardened by quenching in water and then drawn in the same general way that simple steels have been drawn, presumably for thousands of years. It will cut at a higher speed than a simple steel, say 40 ft. per min. on steel having a tensile strength of 80,000 lbs. per sq. in., and is also more durable.

The erosion of the bore of cannon by the powder gases is held to depend largely on the fusion point of the metal of the tube or liner, the higher the point the greater being the resistance to erosion. So it has been found that the nearer the metal comes to being pure iron the higher its fusion temperature and the better it resists erosion, but

the strength required compels a certain amount of hardening and strengthening elements to be present in the steel. Tungsten raises the strength and possibly the temperature of fusion, and so has been employed for the tubes of cannon, particularly by the Government of Austria. Arnold and Read found that steel with 0.71 per cent. carbon and 5.4 per cent. tungsten had in the annealed state a tensile strength of 88,900 lbs. per sq. in., an elastic limit of 60,200 lbs., an elongation of 20 per cent., and a contraction of area of 34.7 per cent., values that compare favourably with those of the steels usually employed in the manufacture of cannon. The strength and hardness of these steels may be greatly increased by heat treatment involving quenching and with only relatively small decrease in ductility.

Simple Chromium Steel.

Simple chromium steels, though among the earliest if not the first of the alloy steels to be made, are not now largely used, though they are used for quite a variety of purposes. In combination with other alloying elements, however, chromium is still one of the most important constituents of alloy steels. Simple chromium steel (content of chromium 0.4 to 2 per cent.) is made by either the acid open-hearth or crucible process. If made in crucibles the chromium in the form of ferro-chromium is made a part of the original charge, but if made in the open-hearth furnace the ferro-chromium is added just long enough before casting for the alloy to be melted and well mixed with the charge. At steel-melting temperatures chromium has a greater affinity for oxygen than has iron, and therefore if any oxygen, either free or in the form of oxide of iron, comes in contact with melted steel that contains chromium, some of the chromium is wasted. It is not oxidised as rapidly as silicon and manganese, however, and therefore has little deoxidising effect when added to an oxidised iron bath, the oxides and gases being controlled by other means.

Composition and Properties of Heat-treated Simple Chromium Steels.

Sample	Constituents. C.	Mn.	Si.	S.	P.	Cr.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1 ..	0.70	0.54	0.09	0.01	0.01	0.70
2 ..	0.70	0.54	0.09	0.01	0.01	0 70
3 ..	0.70	0.54	0.09	0.01	0.01	0.70
4 ..	0.40	0.78	0.54	0.02	0.01	0.92
5 ..	0.40	0.78	0.54	0.02	0.01	0.92
6 ..	0.91	0.35	0.08	0.03	0.01	0.91

Sample No.	Tensile strength	Elastic limit.	Contraction of area.	Elongation in 2 inches	Ball hardness.	Heat treatment. Temperature at which steel was quenched in water	Temperature at which hardness was drawn in air
	Lbs.	Lbs.	Per cent.	Per cent.	Per	° C.	° C
1 ..	129,000	121,700	60	21	235	816	593
2 ..	110,900	105,300	63	26	195	816	649
3 ..	88,000	73,000	68	36	168	816	754
4 ..	143,500	131,600	56	18	242	816	538
5 ..	103,200	90,200	69	26	201	816	714
6 ..	96,800	69,300	63	28	175	—	—

The effect of a chromium content up to a maximum of 2½ per cent. in steel is to increase the hardness moderately when the steel is in the natural state, and particularly when it is in the hardened condition after having been quenched.

Chromium steels are cast, forged, and rolled by the same plant and by the same methods as simple steels of the same or slightly higher carbon contents. Castings are annealed, or heat treated, as the conditions warrant or require to give the most suitable properties for the proposed use. Chromium steels are probably never used in the untreated condition, and their properties in that state are therefore not given.

The longest established use of chromium steels now current is in stamp shoes and dies for pulverising certain gold and silver ores. These shoes and dies contain 0.8 to 0.9 per cent. of carbon, with 0.4 to 0.5 per cent. of chromium. They are preferably annealed to destroy ingotism and so impart some toughness to the metal, which increases their durability in an important degree.

Another long-established use of chromium steel is in 5-ply plates for the manufacture of safes for the safe-keeping of valuables. Hardened chromium-steel rolls having 0.9 per cent. of carbon and 2 per cent. of chromium are used for cold-rolling metals. They are glass hard so that the ball hardness cannot be determined, the ball making no impression. The hardness, as determined by the sclerescope, is 107. Files of chromium steel are excellent, the carbon content being 1.3 to 1.5 per cent. and the chromium content about 0.5 per cent.

An important use of chromium steel is in balls and rollers for bearings. One large maker uses steel containing carbon, 1.10 per cent.; chromium, 1.40 per cent.; manganese, 0.35 per cent.; sulphur, 0.025 per cent.; and phosphorus, 0.025 per cent. Sizes smaller than one-half inch diameter are heat-treated by being quenched in water from 774 deg. C. (1,425 deg. F.) and then drawn to 190 deg. C. (375 deg. F.) for half an hour. For larger balls the quenching temperature is 802 deg. C. (1,475 deg. F.). The second heating does not produce an oxide colour, but is enough to let down in some degree the internal stresses due to the irregular cooling or quenching, so that the balls are less liable to crack spontaneously or to be broken in use. The strength of a good, well-treated ball is prodigious, a ball three-fourths of an inch diameter, tested by the three-ball method, sustaining a load of 52,000 lbs. On the small area of contact the intensity of the pressure amounts to over 1,000,000 lbs. per sq. in. The Society of Automobile Engineers recommends less chromium than that given above, or 1 to 1.2 per cent.

A former important use of these steels was in armour-piercing projectiles. The greater part of projectiles, however, contain some nickel also, as noted in the discussion of nickel-chromium steels. Chromium steels are preferred by some builders in certain motor-car parts, though most makers of cars prefer nickel chromium.

Manganese Steel.

Manganese steel in the commercial meaning of the name is a variety of iron containing 11 to 14 per cent. of manganese and 1.0 to 1.3 per cent of carbon. The original patents covered alloys of iron with 7 to 30 per cent. of manganese, but the steels within the limits of composition given have the greatest strength and ductility of any, and are always meant when manganese steel is ordered without further qualification. The bulk of the manganese steel made at present is put into castings. The use of hot-worked (rolled or forged) manganese steel is now of importance for rails.

Manganese steel is still made in the ladle, according to Hadfield's expired patents, by the mixture of decarburised iron and 80 per cent. ferro-man-

ganese. The decarburised iron is prepared either by the pneumatic process, being blown in some one of the many modified pneumatic converters, or in the Siemens furnace. As ferro-manganese forms such a large proportion of the charge, about one-seventh, it must be melted, or nearly so, before being added to or mixed with the decarburised iron, or the resulting steel would be too cold. The ferro-manganese is usually melted in graphite crucibles or pots, which is an expensive way, but not yet generally superseded. The pots are heated in ordinary melting holes. They usually may be used to melt eight or ten charges, whereas in steel melting they average less. This longer life when melting ferro-manganese comes from both the lower melting temperature needed and the absence of solution of the graphite of the pot by the metal, common ferro-manganese being saturated with carbon, whereas molten steel eagerly dissolves any carbon with which it comes in contact. The ferro-manganese need not be completely melted, which, of course, would not be permissible with the steel.

The decarburised iron used should have a low carbon content, not over 0.10 per cent., so that the resulting steel may not have more than is desired. The proportion of carbon to manganese in the steel will, therefore, be a little more than in the ferro-manganese. After the manganese steel has been made in the ladle it should be cast as soon as practicable if it is to be used for castings, but if it is to be used for ingots a little time should be allowed for the silicate formed within the metal to collect and float to the top.

The quantity of manganese is proportioned to the size of the charge of decarburised iron, with allowance for loss through oxidation of an amount equal to about 1½ per cent. of the steel. Thus 14 per cent. is added to yield 12.5 per cent. in the steel. Everything is weighed—the stock before melting, the iron added to the vessel if decarburised by the pneumatic process, the molten ferro-manganese, which is put in the ladle first, and the decarburised iron are all weighed, the weight of the decarburised iron giving the weight of the molten steel in the ladle. When the decarburised iron is prepared in a tilting Siemens furnace, a part may be taken out at a time and made into steel, the amount of iron being weighed by a suspended weighing machine on the crane.

Earnest efforts have been made to melt ferro-manganese in a cupola because of the high cost of melting in pots, and some has been so melted in a commercial way. When the ferro-manganese is melted in a cupola there is more loss of manganese, which offsets, in part at least, the lower cost of melting. The loss is diminished to a large extent by charging the ferro-manganese in the centre of the cupola with coke around the outside so that the metal is largely protected from free oxygen of the blast, which would oxidise manganese if it came in contact with it. It is a matter for calculation which is to be chosen for any given conditions as being the cheaper or, all things considered, the most advantageous.

Another effect of the waste of manganese from the ferro-manganese used in making manganese steel is that the carbon content is higher, and perhaps undesirably so, in the finished steel because of its concentration due to the waste of manganese. Carbon is not oxidised under usual conditions in fused ferro-manganese because of the presence of the large excess of manganese which seizes any oxygen that reaches the alloy.

Manganese steel is usually made and handled in clay-lined ladles. Basic-lined ladles present some advantages, but clay is used because it is so much cheaper and more easily made into a lining. Such a lining is, of course, to be classed as acid, and sometimes strongly so, when quartz in the form of sand or ganister is mixed with the clay. Molten manganese steel in an acid-lined ladle continually makes a fusible and liquid slag, which is chiefly a silicate of manganese, green in colour. It is formed of oxide of manganese, which is continually being oxidised by atmospheric oxygen, and the ladle lining. A little green silicate rises and joins the slag from within the metal, being formed from the silica contained in the decarburised iron and the oxide of manganese formed by substitution of manganese for iron in the oxide of iron in the metal. The thin fluid slag is troublesome, as it is not easily kept from entering the moulds with the steel, where it is likely to cause a defect in the ingot or casting.

To avoid the trouble from the very liquid slag a "coffee-pot" ladle is sometimes used, which is provided with a spout like that of a coffee pot, attached at one side and connecting with the ladle interior at the bottom. This arrangement acts effectively to skim the slag, which cannot enter the spout until nearly all the steel has been poured out of the ladle. The corrosion of the ladle lining is deepest at the slag line when the ladle is full, as the slag has more time to act on the lining at that level than at any other.

Because of its large content of carbon, silicon, and manganese, the latter fusing at 1,260 deg. C., manganese steel melts at about 1,325 deg. C., a temperature lower than that of simple steel, and one that favours the running of intricate castings. For the same reason manganese steel, containing so much gas solvent, is usually free from gas holes; but if the decarburised iron of which it is made is too hot, and therefore too heavily charged with gases, the solvent powers of the silicon and manganese may be exceeded, and the steel be saturated with gases, the ingots or castings being consequently infested with blowholes by the gases liberated in cooling.

In making manganese steel one composition is practically standard. The usual analyses of manganese steel lie between the following limits:—Carbon, 1.0 to 1.3 per cent.; silicon, 0.3 to 0.8 per cent.; manganese, 11.0 to 14.0 per cent.; phosphorus, 0.05 to 0.08 per cent. The sulphur content is so low as to be negligible in manganese steel as in other iron-manganese alloys, from which any sulphur that may get in is quickly eliminated by the manganese, probably as sulphide, which rises to the surface or enters the slag. In the open the sulphur is burned by the oxygen of the air, forming sulphurous acid (SO_2), which may often be smelled coming from the molten steel.

Low-manganese steels with 7 to 8 per cent. of manganese are finding some use, having a higher and better defined elastic limit than the regular grade, and yet with considerable though much less ductility. They are also cheaper to make. They do not flow under impact as freely as the regular commercial grades, because, no doubt, of their martensitic structure.

Manganese-iron alloys containing 3 to 10 per cent. of manganese and 1 per cent. of carbon are martensitic. With the manganese over 10 per cent. the structure is austenitic. The steels having 7 to 10 per cent. of manganese are so different from commercial manganese steel that another name should be given them to avoid confusion. The name "loman steel," an abbrevation of "low-

manganese steel," has been applied to them, and seems to be suitable as a short distinctive name.

Manganese steel is a hard self-hardening steel, owing this property to its composition and not to treatment. It cannot be softened by heating followed by slow cooling. It is, for a metal, a poor conductor of electricity. It has a high coefficient of expansion, small patterns being made with a shrinkage of 5-16 in. to 1 ft, which sometimes is not quite enough. A shrinkage of 5-16 in. to 1 ft. gives a mean coefficient of expansion of about 0.000024 per deg. C. In respect to specific gravity manganese steel is not to be distinguished from simple steels of the same carbon content.

Perhaps the most remarkable property of manganese steel is its almost total lack of magnetic permeability and susceptibility. This metal, containing 85 per cent. of iron in a metallic form, is so slightly attracted by a magnet that the pull cannot be felt with the hand, whereas magnetic oxide of iron, containing about 70 per cent. of iron in a non-metallic form, is strongly attracted. A magnetometer or even a pocket compass needle will usually detect magnetism in commercial manganese steel, especially if a test be made soon after the steel has been in contact with a magnet, but the amount that may be so detected is extremely small. For most practical purposes it is zero.

The properties of manganese steel in the raw state are much like those of other raw high-carbon steels, the metal being very hard, but its ductility being practically negligible. The steel, because non-magnetic, may be used for purposes requiring a hard, non-magnetic metal, if it is not liable to shock. With better tool steels, which may make machining manganese steel a commercial operation, the metal may find a field of use in electrical apparatus, replacing some brass or other non-ferrous metals because of its lack of magnetic qualities and lower cost.

Heat Treatment of Manganese Steel.

As used, manganese steel is almost universally water-toughened according to the method Hadfield set forth in his early papers. This treatment consists in heating the whole article to about 1,050 deg. C. and then cooling it as quickly as possible by immersing it in cold water, the colder the water and the more of it the better. It will not do to heat only a part of the piece for quenching, and if a part of a toughened article becomes heated to redness or near it by accident or design the whole piece should be reheated and again quenched to give it proper qualities for use.

No time should be lost in completing the heating and quenching after the piece has become red-hot to avoid oxidation as completely as possible. Manganese steel is a poor conductor of heat, a factor that interferes with its heat treatment and tends to limit the thickness of the steel that may be profitably treated. This limit of thickness is generally taken as 4 in., though somewhat thicker pieces in which the presence of internal cracks in the central parts would not be ruinous are treated in particular instances.

A thick piece of manganese steel must be heated at a slow rate. The heating cannot be properly done by placing the piece when cold in a hot furnace. The furnace if hot from previous use must be cooled down nearly to atmospheric temperature or to that of the piece to be toughened, if it is not cold, before it is placed in the heating chamber. If the furnace is much hotter than the piece the poor heat conductivity of the metal retards the passage of heat to the interior, and the temperature of the skin rises rapidly, because of which and because of the high coefficient of expansion of the metal the exterior is expanded so much sooner than the interior that the latter is likely to be torn apart, the cracks extending outward from the centre toward the surface until the stresses are sufficiently relieved or they reach metal too much softened by the heat to crack.

The hardness of toughened manganese steel is unique, and it may be termed a tough hardness and not a flinty hardness. Such steel may easily be dented with a hammer or marked with a file or chisel, but cutting it to a useful extent is almost impracticable, so that such finishing as is necessary is usually done by grinding with abrasive wheels.

The water toughening of manganese steel gives it great ductility—greater as to elongation, perhaps, than that of any other steel and exceeding sometimes 50 per cent. in 8 in., although its high degree of hardness is not greatly altered. This high ductility in combination with the great hardness of manganese steel gives it great resistance to abrasive wear as well as safety from breakage. Practically all manganese steel is used in the toughened state.

In the pulling test the percentage of contraction of area is less than the elongation, a result directly opposite to that with simple as well as most alloy steels, in which the percentage of contraction is usually twice or more that of the elongation. The pulled test piece has a rather uniform stretch throughout its length, whereas simple steels, as is well known, have a largely increased amount of stretch near the point of fracture. When a piece of manganese steel is pulled, the increase of strength due to cold working (stretching) is greater than the decrease in cross section due to contraction, so that a stretched part becomes stronger than the unstretched parts, and elongation then occurs at another place. As the pulling is continued, all parts of the pulled section stretch one after the other, with the result that when the piece is finally ruptured the stretch has been comparatively uniform. There is, indeed, an increased local extension and contraction close to the point of rupture, as with other ductile steels, but it is less marked in the manganese steels.

The elastic limit of manganese steel is unexpectedly low and not well defined, as the steel yields at a gradually increasing rate when pulled, as in testing, giving no point that, strictly speaking, can be said to be the elastic limit or even yield point. The strain diagram has no jog.

Owing to its lack of elastic limit and to its high ductility, manganese steel is prone to flow under stress, and it does not have high resistance to compression or to continually repeated blows of a hard mineral or other material that will gradually batter it out of shape. The hardness by Brinell's ball test of manganese steel is low, running usually about 190. The merit number obtained by multiplying the figure representing the tensile strength of a material by the figure representing its elongation gives roughly a fair idea of the amount of work that must be expended upon the material to break it—that is, its strength must be overcome through a distance represented by its ductility before it will be broken. The merit number of manganese steel is perhaps the greatest of all known steels. The merit numbers of various metals are given below.

Of course, each of these metals yields to stress within its elastic limit, so that some work must be expended on it to strain it up to that point.

With a nonductile metal, such as cast iron or even raw managanese steel, this is the reason for such small resistance to shock as it has. The elongation of 0.5 per cent. given in the table is high for cast iron, but its power to absorb energy without breaking is increased by its ability to be strained within the elastic limit. If a material were to have no ductility and were perfectly rigid, the slightest blow would break it.

Merit Numbers of Various Metals.

Metal.	Tensile strength.	Elongation.	Merit number.
	Lbs.	Per cent.	
Manganese steel	140,000	50	7,000,000
Soft steel	60,000	30	1,800,000
Tool steel	130,000	5	650,000
Cast iron	20,000	0.5	10,000
Nickel steel, natural	95,000	21	1,995,000
Nickel steel, heat-treated ..	207,000	14	2,898,000

Manganese-Steel Castings.

Manganese-steel castings are made in dry sand, in green sand, and in some instances in iron moulds, the considerations leading to the adoption of any particular material being much the same as with ordinary simple steel castings, such as danger of pulling apart or cracking in cooling, misrunning, or failure to fill the mould properly, and breaking or washing of the mould, and numerous others. The high coefficient of expansion of manganese steel must be considered, as it increases the liability of a casting to be cracked or pulled apart by shrinkage in cooling.

Manganese steel is prone to settle as it solidifies, demanding, for a given massiveness of design, larger sink heads than simple steels to feed the casting properly and prevent settle holes.

Even more than with other steel castings it is important that manganese-steel castings be so designed that the mass is fairly uniform throughout, or in particular that no part is much thicker than the rest. If a thick part is unavoidable, it should be connected with a sink head by metal as thick or nearly so. Thus, bosses and heavy fillets, often advisable in iron and simple steel castings, should be avoided because of the local increase of the mass they cause. The trouble is that a heavy part incompletely fed will be unsound in its central parts. A hole or recess cored in, if permissible, may prevent the central cavity, or an iron or soft steel core may be imbedded in the thick part, which, by hastening the solidification of the metal, may prevent the formation of holes or loose metal there.

Uses of Manganese Steel.

Manganese steel is used in equipment employed in the mining, milling, and treatment of ores and other mineral products, quarrying and rock-dressing, digging and dredging, railway tracks, parts of machines exposed to gritty wear, and burglar-proof safes and vaults for the safe-keeping of money and valuables. Because of its low-yield point manganese steel does not give satisfaction in many lines for which otherwise it seems to be eminently fitted. When the service required is such that the resistance of the metal to flow is not exceeded, the results are often excellent. When for any reason the pressure at the point of wear passes the flowing point the results are disappointing, though even then they may be better than those obtained by the use of any other material.

(To be continued.)

Correspondence.

Contrasts in Foundry Methods.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—As a working moulder who never loses the opportunity to gain knowledge from other moulders on foundry practice and conditions, I have read Mr. Miles' article on "Contrasts in Foundry Methods" with mixed feelings of regret and appreciation. If the problem of the scientific and economical production of castings is going to be solved, it will have to be met in a more tolerant and scientific way than suggested by Mr. Miles. By what process of reasoning does he deduce the conclusion that the high wages paid to some labourers act as an incentive to greater usefulness and interest in the work, and that the same conditions make the highly-paid moulder the senseless workman he writes about. In highly-paid districts a greater demand is made on the intelligence, skill and power of the moulder. Competition will always keep up this high standard of efficiency.

What is said about the textile foundry is true. The simplicity and regularity of the work allows it to be more easily organised than the complex work of a general jobbing and engineering shop. Between the two are a large number of shops doing specialised work, each with its own peculiar problems to solve.

How can a foreman have perfect organisation in his shop when he cannot determine from day to day the nature of the work to be made, and is limited in floor space? The result of these conditions is that in the majority of shops in one highly-paid district it is common practice for one or more moulders to be given a piece of work to start in a place from which a casting has just been removed, with all the scrap, loose irons, cinders, and accumulated dirt from a previous cast; so they have to carry dozens of buckets of water before they can commence to dig a hole, and by the time they are ready to begin moulding they are mentally and physically unfit to do justice to the work. An ignorant foreman in such cases is satisfied in his own mind that they are not doing all they might.

Many shops could be named, some with 60 and 70 moulders, with two ¼ in. and ½ in. riddles, one staking hammer and loosening bar, two vent wires, a general scarcity of box pins, bolts, hook-bolts and screw-keys, 30 moulders sharing about 4 pig and flat rammers. Again, take the uselessness of cast iron gaggers that can only be once used, the cost and waste of energy to make them.

Thus, before we get to the stage suggested by Mr. Miles of allowing labourers to dip gaggers or use a flat rammer round a pattern, there is a lot of dirty and uncongenial work that can be taken from the moulder which he dislikes to have to do, and will not consider it a crime to allow an unskilled worker to perform. Practical moulders see this evil, and know who is responsible. The full responsibility must rest with the employer, either for want of capital or knowledge as to the requirements of his works; his short-sighted policy in looking at the first cost in buying the necessary material, and not seeing how costly is the waste of labour power.

The trouble is often due to the engaging of managers and foremen of men without practical experience at the trade, with little organising ability, without a thorough knowledge of human nature. The human element is one of the most important factors in foundry life, and the average moulder is not so ignorant that he cannot appreciate and respond to any system that makes his work easier and more congenial, and gives the joy in labour all desire.

Yours etc., G. E.

Dynamic Properties of Steel Castings.*

By J. Lloyd Uhler.

The recognised importance of knowing something more than the static properties of steel employed in the manufacture of castings for various uses, such as locomotives, turbines, electric cranes, etc., led some of the steel foundrymen to make a thorough study of their product in recent years. It is just as essential to know the probable behaviour of steel in service, which is subjected to shock or alternating stresses, as it is to know the static properties of the steel used. Too much reliance generally is placed upon the limited information furnished by the static tension test, with the result that numerous failures in practice are often inexplicable, and for that reason experiments were begun to look for some other device which, in a commercial manner, would divulge something concerning the other properties of the castings.

It has been long understood that materials are liable to degenerate in quality at a rate depending upon the service which they undergo. The numerous every-day failures which cannot be accounted for are forcing metallurgical investigators to make research and investigations into the action on steel exerted by complicated forces and they realise the fact that resistance to fatigue is not entirely a function of static strength.

In 1907 the manufacture of vanadium steel castings was started on a small scale and one of the claims for this alloy was resistance to fatigue. This claim was investigated to determine whether it could be substantiated, and in July, 1907, test bars of carbon and vanadium steels were prepared, which were tested, by courtesy of the Pennsylvania Railroad Company, at Altoona, Pa., on an improvised vibratory machine which was used for making tests of staybolt iron. This machine was an old slotter that had been equipped for making vibratory tests and was provided with a registering device which gave a complete record of the number of alternating stresses. The bar was fastened rigidly in a vice and extended out to the slotter arm, 8 in. distant. It had a plate fastened to the arm with a hole through it so that the free end of the test bar, which was supplied with a round nut, could be placed in it with an allowance of ¼-in. play, thereby allowing the test bar to be deflected ⅛ in. each side of the neutral position. This machine gave only 30 vibrations per minute. The size of the bar was ⅝-in. round and 15 in. long.

The Turner and Landgraff testing machine was next employed by investigators. This is the new modification of Wohler's method of dynamic testing, which was introduced in 1905 by Prof. Arnold, of Sheffield University. In making this test the piece is held securely in a vice at one end and is moved backwards and forwards by a slotted arm which communicates to the piece successive permanent distortions in each direction, produced by impact and followed immediately by a pushing motion. As a result, the test piece is fractured finally on the line of the vice, at which point the most severe stresses are created. The slotted arm is on a crank, so that the pushing motion is performed without the interfering factor of rub, as the slotted arm describes the same arc as the distorted piece.

The next series of tests were made on the Wohler dynamic or endurance-testing machine. It subjects a specimen to a reversal of bending stresses on a rapidly-rotating bar, but this form of testing often gives widely varying results, even from the same bar, and does not necessarily detect dynamically weak steel. Prof. Arnold's original idea in devising this test was to introduce the Wohler method to practical use by reducing the time needed to make this test, namely, from days and hours to minutes. His argument was that instead of making the test within the elastic limit, by going just beyond it the result would quickly reflect the liability to fracture within the elastic limit, under stresses applied for a long period. But it was found that the test predicted liability to fracture from causes altogether aside from the Wohler fatigue phenomenon and registered potential brittleness, which the Wohler test not only failed to detect, but pronounced absent.

The investigators then made a series of tests employing a vibratory machine built especially strong, so that a specimen of steel 1¼ in. in dia. and having an elastic limit of 125,000 lbs. per sq. in. could be tested without causing the frame of the machine to vibrate.

The results of experiments made on a Turner & Landgraff machine are given in the accompanying table. The test pieces were 8 in. long, and by reversal two tests could be obtained from one sample, thereby securing an indication of the uniformity of the metal represented by the test piece. Also the thoroughness of the annealing was thus ascertained, as steel, according to its composition, or rather according to the manner in which the component elements are inter-united, is liable to deteriorate rapidly, or crystallise under the fatigue of continued reversals of stress. The data were gathered with the view of determining the results of impact or fatigue upon steel of different carbon compositions which had been annealed thoroughly in commercial foundry practice. The tabulated record shows that the static results are practically what could be expected from the different chemical compositions, yet the dynamic results prove that even though the chemical analyses are approximately the same in several cases, nevertheless the number of impact stresses is different, due as far as experiments have indicated, to the mechanical energy dissipated during a cycle of stress. It would seem that the lost energy must be transformed into heat, that there must be some form of internal friction in the material that causes wear and structural damage to occur, and that if the action is continued long enough the material will be ruptured. It seems reasonable to consider the amount of structural damage during a cycle of stress to be proportional to the energy transformed into heat, or in other words, to the area of the hysteresis loop. The shape of this loop remains similar to the shape developed under early impact of stress.

I believe that a formula which assumes that the same destructive action which occurs under high stress will continue to act with diminished intensity under low stresses, has some indirect evidence in

* Abstract of Paper read before the American Foundrymen's Association.

its favour and is a safer guide for designers than a fixed endurance limit below which destruction action is assumed to cease.

From my personal experience and observation, I do not believe that sufficient importance is assigned to dynamic strains in steel. The object in testing steel is to secure a product which will give longer life in the service in which it is used. Practically the only tests made are static, and while they definitely determine the efficiency of the steel in resisting severe strains, experience has shown that the strength of the steel does not definitely determine its ability to resist fatigue; and I am convinced that more failures result from the innumerable minor vibratory strains than from those which are more severe.

Dynamic and Static Results Obtained on

Castings made from steel containing.....0.20 to 0.25, 0.25 to 0.30, 0.33 to 0.40 and 0.40 to 0.50 per cent carbon
Castings made from vanadium steel containing.....0.23 to 0.28, 0.38, 0.47 and 0.49 per cent carbon
Castings made from chrome nickel steel containing.....0.31 to 0.38 per cent carbon

Heat No.	Elastic limit, per square inch.	Ultimate strength, per square inch.	Elongation, per cent, in 2 inches	Red. of area.	Vibration.	Average vibration.	Chemical analysis, per cent. Carbon.	Phosphorus.	Manganese.	Sulphur.	Silicon.	Vanadium.	Nickel.	Chrome.
7540	34,900	67,400	27.5	42.46	2,354		0.205	0.043	0.700	0.032	0.270	.....	.....	.....
7054	34,880	63,400	39.0	55.02	2,453	2,437	0.205	0.043	0.700	0.032	0.270	.....	.....	.....
					2,248									
					2,693									
333D	32,040	70,400	28.5	43.8	3,520		0.240	0.045	0.570	0.038	0.249	.....	.....	.....
333D	32,200	69,900	31.0	51.0	2,280	3,102	0.240	0.045	0.570	0.038	0.249	.....	.....	.....
333D	31,130	70,040	30.0	47.9	3,510		0.240	0.045	0.570	0.038	0.249	.....	.....	.....
8875	37,160	71,700	33.0	48.2	2,010	3,449	0.250	0.036	0.600	0.024	0.230	.....	.....	.....
8875	36,710	70,180	31.5	52.8	1,826		0.250	0.036	0.600	0.024	0.230	.....	.....	.....
229D	37,240	69,460	29.5	49.6	3,128	1,918	0.250	0.032	0.610	0.028	0.259	.....	.....	.....
229D	39,600	69,680	29.5	50.1	3,770		0.250	0.032	0.610	0.028	0.259	.....	.....	.....
227D	36,950	71,650	29.0	45.2	3,972	3,228	0.270	0.031	0.580	0.028	0.277	.....	.....	.....
227D	36,740	71,460	29.0	46.8	2,483		0.270	0.031	0.580	0.028	0.277	.....	.....	.....
470C	38,510	76,700	29.0	44.1	3,512		0.270	0.047	0.630	0.027	0.280	.....	.....	.....
470C	38,050	76,100	29.0	46.9	2,940	3,104	0.270	0.047	0.630	0.027	0.280	.....	.....	.....
470C	37,240	76,500	28.5	47.4	2,860		0.270	0.047	0.630	0.027	0.280	.....	.....	.....
473C	38,560	79,660	25.0	45.5	3,255		0.280	0.044	0.630	0.026	0.329	.....	.....	.....
473C	38,050	80,680	24.0	42.5	3,522	3,522	0.280	0.044	0.630	0.026	0.329	.....	.....	.....
473C	38,210	78,960	27.5	45.2	3,378		0.280	0.044	0.630	0.026	0.329	.....	.....	.....
624C	34,750	73,400	25.0	41.3	3,803	3,867	0.330	0.034	0.610	0.030	0.290	.....	.....	.....
624C	35,800	78,380	22.0	44.3	3,930		0.330	0.034	0.610	0.030	0.290	.....	.....	.....
461C	44,790	91,100	21.0	27.5	3,029		0.370	0.043	0.700	0.025	0.305	.....	.....	.....
461C	45,480	91,970	21.5	36.5	3,066	3,258	0.370	0.043	0.700	0.025	0.305	.....	.....	.....
461C	43,930	89,870	22.0	39.4	3,679		0.370	0.043	0.700	0.025	0.305	.....	.....	.....
481C	43,280	88,580	24.5	37.7	3,009		0.375	0.044	0.740	0.029	0.291	.....	.....	.....
481C	.....	.....	....	....	2,945	3,115	0.375	0.044	0.740	0.029	0.291	.....	.....	.....
481C	.....	.....	....	....	3,393		0.375	0.044	0.740	0.029	0.291	.....	.....	.....
447D	40,600	84,720	25.0	40.1	2,958	3,154	0.386	0.046	0.680	0.035	0.300	.....	.....	.....
447D	40,100	82,710	23.0	33.8	3,350		0.386	0.046	0.680	0.035	0.300	.....	.....	.....
9034	57,460	96,740	19.0	30.7	1,999	1,999	0.400	0.049	0.730	0.029	0.310	.....	.....	.....
9034	60,100	97,340	17.5	23.0	.....		0.400	0.049	0.730	0.029	0.310	.....	.....	.....
9215	45,660	76,620	27.5	51.1	3,000	3,265	0.235	0.047	0.575	0.030	0.250	0.145	.....	.....
9215	42,590	78,200	31.0	51.8	2,904		0.235	0.047	0.575	0.030	0.250	0.145	.....	.....
464C	48,550	82,620	26.0	42.7	2,978		0.235	0.028	0.590	0.025	0.280	0.180	.....	.....
464C	48,530	79,900	25.5	49.8	2,722	3,057	0.235	0.028	0.590	0.025	0.280	0.180	.....	.....
464C	46,740	73,900	29.5	52.2	3,471		0.235	0.028	0.590	0.025	0.280	0.180	.....	.....
479C	47,330	75,000	29.5	53.8	3,360									
479C	46,440	72,120	29.5	52.8	3,054	3,273	0.245	0.038	0.610	0.029	0.310	0.190	.....	.....
479C	47,420	79,460	25.5	49.1	3,406		0.245	0.038	0.610	0.029	0.310	0.190	.....	.....
77E	48,400	77,500	27.5	45.6	3,096	2,952	0.250	0.042	0.572	0.023	0.250	0.194	.....	.....
77E	49,380	80,120	27.5	48.0	3,434		0.250	0.042	0.572	0.023	0.250	0.194	.....	.....
306D	47,500	75,040	27.5	50.0	4,218		0.250	0.038	0.550	0.030	0.254	0.200	.....	.....
306D	46,810	74,980	29.0	53.2	4,102	4,074	0.250	0.038	0.550	0.030	0.254	0.200	.....	.....
306D	.....	.....	....	...	3,902		0.250	0.038	0.550	0.030	0.254	0.200	.....	.....
433E	47,750	82,870	23.5	44.2	4,510		0.255	0.041	0.580	0.035	0.268	0.178	.....	.....
433E	48,010	80,860	23.5	44.2	4,356	4,192	0.255	0.041	0.580	0.035	0.268	0.178	.....	.....
433E	48,310	83,540	22.0	42.9	3,710		0.255	0.041	0.580	0.035	0.268	0.178	.....	.....
372D	47,500	80,000	24.0	39.0	2,966	2,966	0.260	0.035	0.510	0.028	0.260	0.203	.....	.....
67E	49,060	82,080	26.0	44.5	3,190	3,335	0.260	0.039	0.624	0.025	0.290	0.205	.....	.....
67E	47,420	78,480	28.0	48.0	3,480		0.260	0.039	0.624	0.025	0.290	0.205	.....	.....
74E	48,720	79,320	26.0	47.7	3,476	3,476	0.260	0.043	0.576	0.022	0.260	0.190	.....	.....
74E	49,380	80,640	25.0	50.1	.....		0.260	0.043	0.576	0.022	0.260	0.190	.....	.....
35E	41,760	79,640	28.0	44.2	4,320	3,965	0.265	0.034	0.638	0.023	0.270	0.203	.....	.....
35E	41,190	82,380	26.0	43.6	3,610		0.265	0.034	0.638	0.023	0.270	0.203	.....	.....
226D	48,120	86,220	23.5	40.1	3,834	3,781	0.280	0.026	0.660	0.028	0.306	0.165	.....	.....
226D	48,620	88,720	21.0	38.6	3,728		0.280	0.026	0.660	0.028	0.306	0.165	.....	.....
437E	64,180	111,670	15.0	28.6	2,776	2,567	0.380	0.038	0.700	0.034	0.335	0.188	.....	.....
437E	61,750	113,430	14.5	24.9	2,358		0.380	0.038	0.700	0.034	0.335	0.188	.....	.....
Double annealed, "Berry"														
414D	75,440	133,840	13.5	20.5	3,053		0.470	0.042	0.730	0.032	0.361	0.185	.....	.....
414D	74,440	140,600	10.0	15.6	3,226	3,351	0.470	0.042	0.730	0.032	0.361	0.185	.....	.....
414D	73,980	133,600	15.0	21.8	3,773		0.470	0.042	0.730	0.032	0.361	0.185	.....	.....
Single anneal, "Dividers"														
9155	83,980	119,010	10.5	15.8	3,009	2,952	0.490	0.036	0.710	0.037	0.310	0.175	.....	.....
9155	86,220	123,090	10.0	15.6	2,904		0.490	0.036	0.710	0.037	0.310	0.175	.....	.....
79-D	61,660	105,750	19.0	48.4	3,810		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	62,400	105,800	17.0	31.9	3,790		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	64,420	106,700	17.0	35.2	3,790	3,831	0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	63,930	105,270	18.0	36.2	3,478		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
79-D	65,920	103,670	19.0	39.9	4,287		0.315	0.039	0.540	0.026	0.306	.....	1.680	0.810
505C	69,500	115,670	16.5	34.0	3,514		0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	70,420	114,350	15.5	29.0	3,889		0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	73,360	113,090	18.0	39.2	3,562	3,818	0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	65,420	113,500	16.5	35.2	4,354		0.372	0.038	0.650	0.015	0.277	.....	1.930	1.050
505C	70,740	111,400	13.5	29.3	3,772		0.372	0.038	0.650	0.015	0.277	....	1.930	1.050

These tests were made on a Turner & Landgraff machine with a throw of $\frac{1}{4}$ inch and a speed of 760.

Continuous Operation in the Ford Foundry.

The practice in the casting of motor cylinders in the American plant of the Ford Motor Company was formerly to pour the moulds in long rows on the floor from hand ladles, the mould then being picked up by an overhead trolley and carried to be shaken out at the end of the building. This process was continuous, but the present process marks an improvement. From "The Iron Age" we take the following notes and illustrations describing the present method:—

The continuous operation has been modified by conducting it on a travelling conveyor, with the result that output has been increased and the floor space required for the work very much reduced. Of no less importance is the advantage gained in that restricting the movement of the moulds to a definite line of travel has permitted the construction of a ventilating hood immediately over the conveyor. This removes all of the gases and clarifies the atmosphere of the foundry to a remarkable degree.

The conveyor extends from the cupola at one end to the shaking-out grids in an annexe at the end of the foundry. The conveyor consists of three parallel strands, the flights of the outside strands travelling toward the cupola and terminating at a cross-over roll-table which delivers from both sides toward the middle strand, the flights of which travel away from the cupola, carrying the poured mould to the shaking-out tables.

The operations of making up the moulds are consecutive and continuous. As may be seen from Figs. 1 and 2, materials and facilities are provided in the form of moulding sand, machines and flasks on either side of the outer strands of the conveyor. Beginning with the placing of bottom boards and flasks at the end of the conveyor remote from the cupola, successive stages of completion include the placing of the drag, barrel cores and cope, in order, as the mould moves along. In the space between the outer and middle strands of the conveyor the port cores and water-jacket cores are stacked and placed in position as the mould passes. The outer strands of the conveyor on which the mould is built up travel at the rate of 6 ft. per min., and the inner strand, which accommodates the moulds from both sides, travels at the rate of 21 ft. per min.

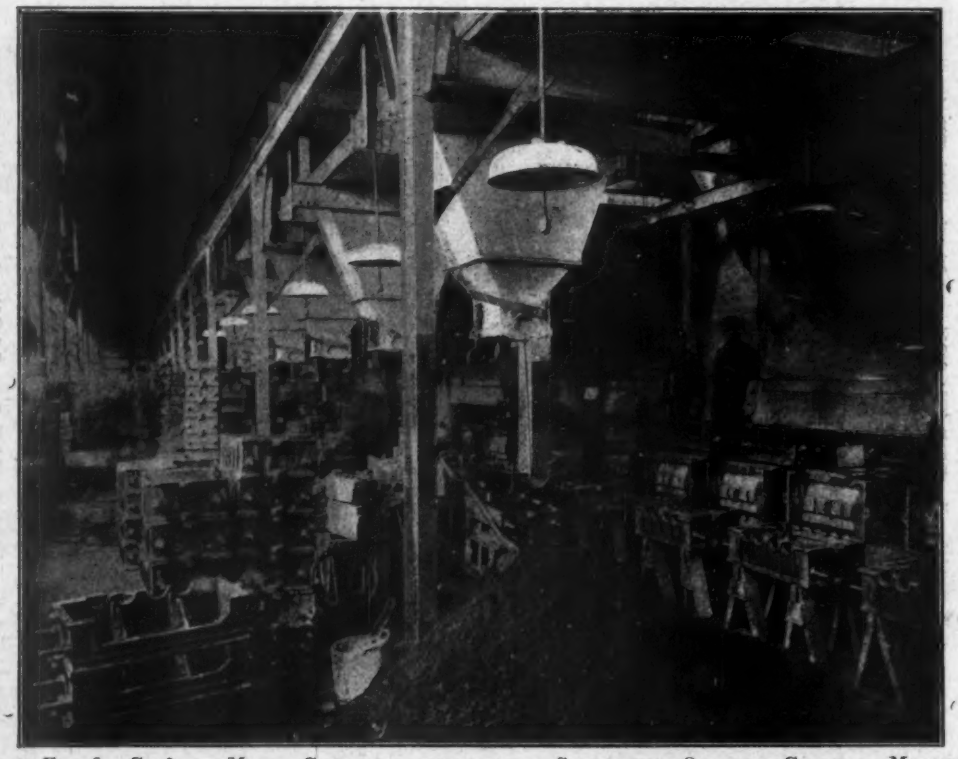


FIG. 1.—CYLINDER MOULD CONVEYOR, SHOWING SAND SPOUTS FROM OVERHEAD CONVEYOR, MOULDS AND GAS HOODS; WORKS OF FORD MOTOR COMPANY.

The moulds are poured as they approach the cupola end of the conveyor from 1,500-lb. ladles. The ladles are suspended from an I-beam trolley which circles the end of the conveyor and transfers the ladle from the cupola to the pouring position. On the basis of 125 lbs. of metal per mould, including the gates, the conveyor handles 6½ tons of

metal per hour, the equivalent in two shifts of eight hours of 1,680 moulds.

The rate of travel and the length of the conveyor are such as to provide a time interval sufficient for the necessary cooling of the casting in transit, and from Fig. 1 the nature of the ventilating hood for the disposal of gases from the mould is apparent. The provision for shaking out the casting and the general lay-out of the conveyor are illustrated in Fig. 3. Immediately beyond the wall which separates the shaking-out room from the foundry proper, four tables are placed, two on each side of the conveyor, and staggered. Above the conveyor a trolley hook is suspended, and as the mould comes through the cope is lifted off to the first table, the drag passing on

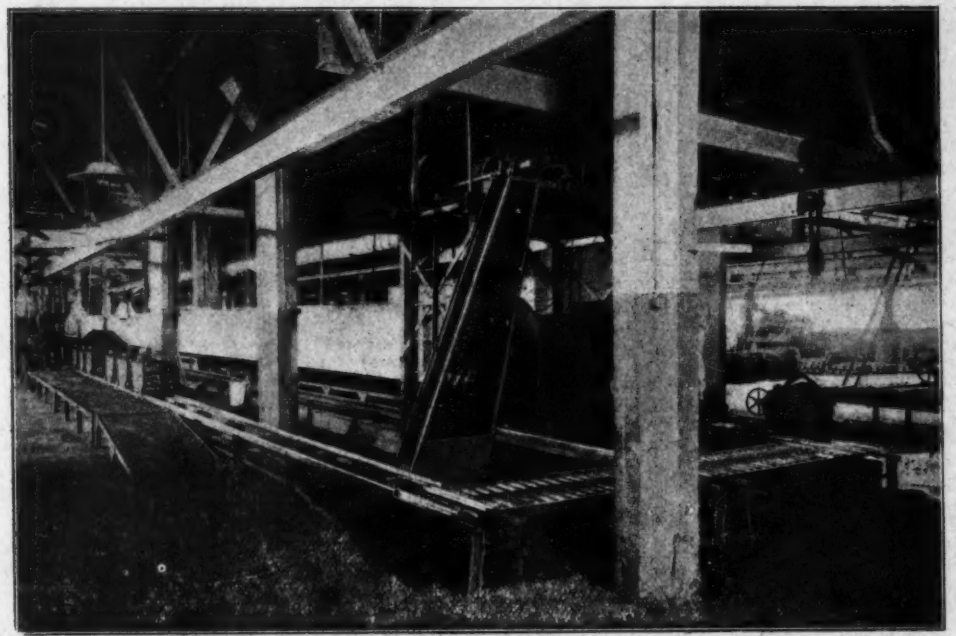


FIG. 2.—CYLINDER MOULD CONVEYOR AT CUPOLA END, SHOWING ROLL TABLE TRANSFER AND CONVEYOR DRIVE; WORKS OF FORD MOTOR COMPANY.

FIG. 3.—DELIVERY END OF CONVEYOR, SHOWING SHAKING-OUT TABLES; WORKS OF FORD MOTOR COMPANY.

to the next table on the same side, where it is dumped over grids, the casting being lifted out with a trolley hook, the sand dropping through to be reclaimed while the flask is piled for return to the foundry. The following mould, coming through at a short interval, is handled on the tables on the opposite side of the conveyor, and so on in alternation.

The conveyor is built of steel angles and channels, the links being supported by and sliding between two channels. The conveyor flights are arranged with upward protruding fingers which engage with the cleats on the bottom boards of the mould, dragging them along the angles which form the framework of the conveyor.

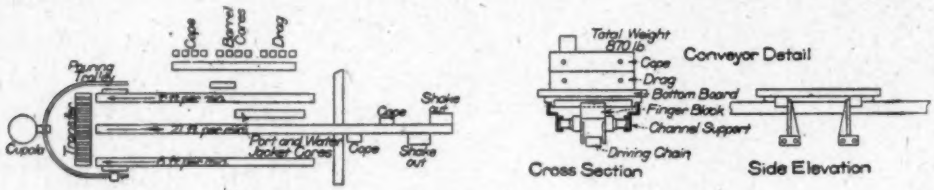


FIG. 4.—DIAGRAM OF CONTINUOUS MOULDING PLANT, AND DETAILS OF CONVEYOR.

The Commonplace Book.

By James Edgar.

The writer, in a somewhat long and varied experience in patternshops and foundries, has met very few men who have kept a commonplace book or taken notes of their work or the work going on around them. Even men who are keen on their craft, and in many cases who have acquired a sound, technical education, depend entirely on their memory. A good memory is as valuable to the foundryman as it is to most men, but there is no reason why the mind should be burdened with details that could be more accurately stored in a notebook. In classwork the students are invariably impressed with the importance of making voluminous notes, and it seems even more important that notes should be taken on practical work as it is always more easy to track abstract subjects through text books. Valuable trade hints passed on by old hands never see print, and are very apt to be forgotten in time. The apprentice—and the journeyman no less—should cultivate a habit of making notes.

It need not be a laborious business nor need it occupy much time. It should not be allowed to stand until the end of the day's work but should be done at the moment when the occasion arises. A small pocket notebook into which can be jotted the many little tit-bits of a day's work is sufficient, although the more painstaking man will rewrite them carefully and collate them later. If it is not possible to get particulars of other work which is being done in the shop, observation will show many methods which cannot be hidden.

But the noting of hints is not all that ought to be done. The patternmaker should make a sketch of each job he finishes, stating whether it is a one-off pattern, a good skeleton, or a solid pattern, and underneath should be noted the cubic measurement of the timber used and the number of hours he has been on the job. In the foundry similar particulars should be noted, say, whether the job has been made in green or dry sand, or in loam from boards, and the weight of the casting. The patternmaker in this respect has a decided pull over the moulder, for he can watch the job from the beginning, and usually having access to the foundry he can compute the total cost of the casting more nearly.

Akin to notetaking is the practice of keeping cuttings from technical journals. Space or other considerations may prevent the student or craftsmen from binding these journals, but if he is wise he will file articles which convey useful information for use at some future date.

It is surprising the amount of knowledge we allow to wantonly slip from us in quite a short time, and this practice of gathering information will not only be found invaluable to the "hand" while he is such, but if he aspires to a foremanship and succeeds he will find it even more valuable. It is the custom with many firms nowadays, especially with patternmaking, to get quotations from outside firms against which their own foremen have to compete. The foreman is then in a somewhat similar position to the rate fixer in a premium bonus shop. He has to refer to similar jobs which have been made in the past, giving the cost of labour and material. Shop management expenses can be added. It is when placed in this position that a "young" foreman appreciates his notebooks. It also gives him confidence in dealing with men, and a better understanding of what a reasonable day's work is.

BRITISH FOUNDRYMEN'S EXCURSIONS.—The Birmingham Branch of the British Foundrymen's Association held its summer outing on July 22, when a party of members and lady friends, numbering forty, drove to Bromsgrove and the Lickey Hills. A halt was made at Bromsgrove to visit the extensive Fine Art Works of the Bromsgrove Guild. The visitors were received by Mr. G. E. Cowper (the manager) and his assistant, Mr. Belk, who conducted them through the brass-finishing shop, the blacksmith's shop, the marble-carving, modelling, and brass-chasing department, the wood-carving and pattern shop, the iron moulding shop, and the brass and bronze moulding shop. The thanks of the foundrymen to the proprietors of the Guild for their kindness in granting the visit, and for the courtesy of Mr. Cowper and Mr. Belk in attending to the party, were conveyed in a resolution proposed by Mr. J. Shaw (President of the Branch), and seconded by Mr. J. J. Howell, senior Vice-President. Mr. Cowper acknowledged the vote for the proprietors and himself. The party thereafter set out for Rednal.

The annual picnic of the Newcastle Branch was held on July 15, when Finchale Abbey was visited. About 60 members and ladies participated, and Mr. H. A. J. Rang (Branch Secretary) acted as guide, and read an interesting account of the place. Tea was provided at the adjacent farmhouse, and the trip generally proved very successful and enjoyable.

Moulding and Casting Cylinder Liners.

By F. Andrew.

The following describes a method of making cast-iron cylinder liners such as used in internal-combustion engines. The writer does not claim anything original in the method, which may be in use elsewhere, but gives it for the benefit of those who still struggle on in the old ways with half-patterns, turned off a board in large, clumsy boxes.

The latter method necessitates the handling and ramming of a larger quantity of sand, requiring extra mixing and drying, while coring up and closing the moulds requires extra time and attention, and "stopping in" at the joints must be carefully done to prevent burst-outs. The resultant castings also will have a fin down either side the whole length of the castings, with occasionally "lapped" joints and eccentric cores.

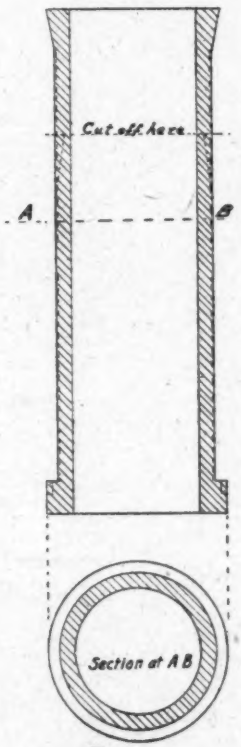


FIG. 1.

With small liners moulding horizontally is perhaps the most suitable, but in the larger sizes the vertical method is without doubt the most economical, and for the purposes of this article a liner weighing about 8 cwts., including head, is taken.

In Fig. 1 are shown two views of a liner in section, and attention is drawn to the difference in pattern when vertically moulded, with plain sides and bottom collar, and those horizontally moulded, with sides and collar as shown by dotted lines. From 8 in. to 12 in. of the upper end is head metal, and is cut off and returned to the foundry as scrap.

Some patterns give a reduced thickness to that part immediately below the head, as this part when the liner is fitted merely serves as a guide to the piston and is an extension of the cylinder proper.

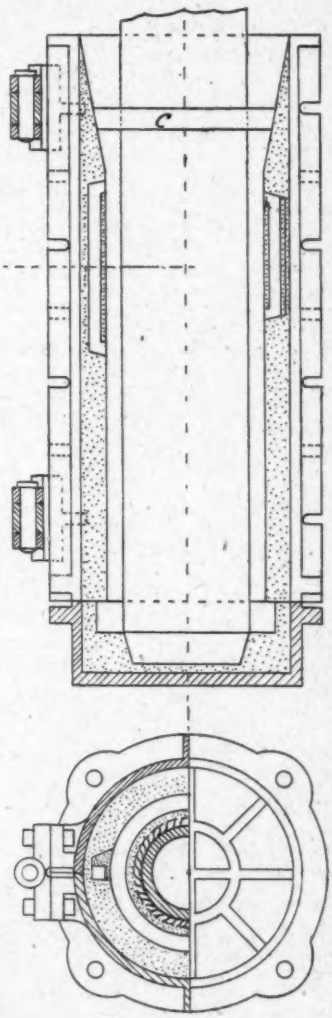


FIG. 2.

This reduced thickness has a bad effect on the castings, as the metal solidifies at this point before that immediately below it and prevents proper feeding by the head metal, thereby causing spongy and open-grained places. These defects show up during boring, for when the tool reaches these parts the stress upon it is reduced, with the result

that a deeper cut is taken and the diameter is increased at that point. To avoid these defects without using chills, the liners are cast equal in thickness at this part with the body of the liner.

In Fig. 2 two views are shown of a mould ready for casting, consisting of two parts as shown in the elevation, the upper portion carrying the body of the liner, with the moulds for the test bars, the lower portion containing the collar and core-print. In the plan of Fig. 2 (left-hand portion)

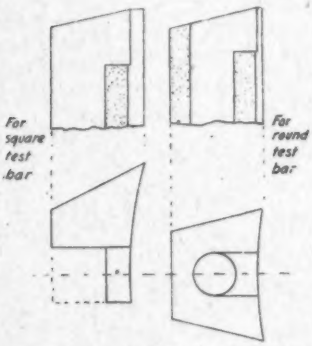


FIG. 3.

a section of mould and core is shown, and also the method of forming the test bar by means of a core, the print for this core being formed by a block rammed up alongside the pattern. A square test

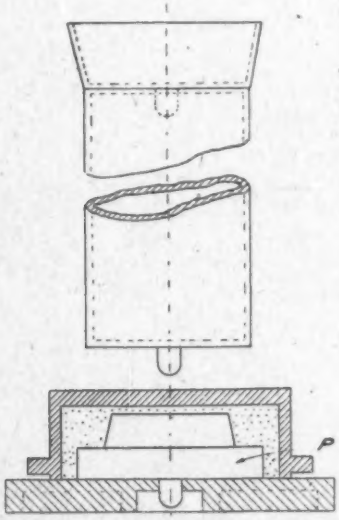


FIG. 7.

bar about 15 in. long, and a round one about 9 in. long, are generally cast on each liner, the round bar being formed by means of a core in a similar manner to the square one referred to above. Enlarged views of these two cores are shown in Fig. 3. The right-hand portion of the plan shows the bottom box empty, and the arrangement of the bars in this box.

To close the mould after drying, two loose pins as shown in Fig. 4 are placed in snugs at opposite sides of the upper box, corresponding to similar snugs in the bottom box, and the upper portion lowered to within about 4 in. of the bottom box and supported in that position on three bricks or wood blocks laid on the box flange. The core can then be placed in position, the space left between the two box parts allowing the moulder to steady the core into the print without damaging

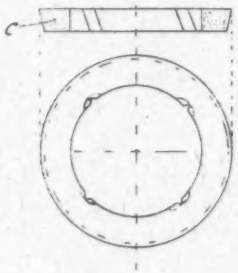


FIG. 5.

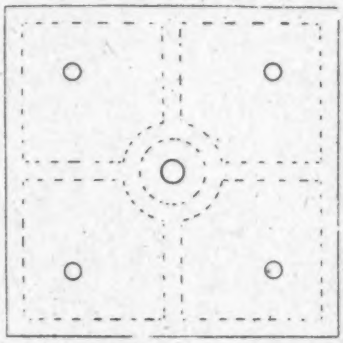


FIG. 6.

same, after which the supports are removed and the upper box lowered on to the bottom box. The pins are removed, four bolts passed through the snugs, and after stuffing wet sand in at the bottom joint to prevent a possible run-out, these are screwed up tight.

The core *c*, also shown in Fig. 5, with four ingates rubbed in, is then passed over the body core, the slope of the outside corresponding to the slope of the head mould. This core keeps the body core central and divides the pouring basin and the casting, being held in position by a few sprigs

FIG. 4.

FIG. 10.

driven into the mould or the body core, which is held down by a chain passing over the top and a 56-lb. weight attached to each end.

Fig. 6 shows the ramming plate, with a central hole for setting the patterns and four smaller holes for setting the boxes, by means of the loose pins already referred to.

Fig. 7 shows the patter *P* for the bottom portion of the mould in position on the plate, the box, plate and mould being in section. The pattern for the body of the mould fits on the plate in the same manner; also the upper portion of the box, the head or sloping portion of the pattern being loose for convenience in ramming round the pattern, and as shown in Fig. 7.

The boxes for the upper portion can be readily made, in halves, from a skeleton pattern as shown

in Figs. 8 and 9, the plate being strickled out, and the hinged brackets handed for opposite halves. Lifting eyes or trunnions may be cast on as desired, and cores set in the mould face as shown in Fig. 10, in positions as indicated in Fig. 9 at *V* to produce a staggered appearance, to avoid fracture of the box which might occur were the cores set in regular and straight lines. These cores form outlets for escape of steam during drying and the escape of gases during casting. The hinges are only required when stripping the castings to avoid the excessive hammering and resultant damage which would result were the box all in one piece.

Starting with good sand, the addition of a small quantity of new sand and coal dust each time the boxes are emptied out will keep the sand in good condition. The amount of sand handled is considerably less than that required for ramming up the moulds horizontally, and therefore less drying is required.

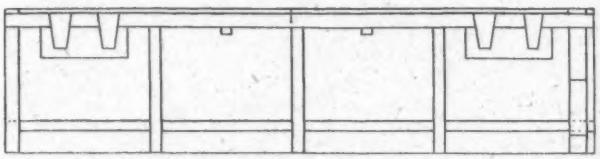


FIG. 8.

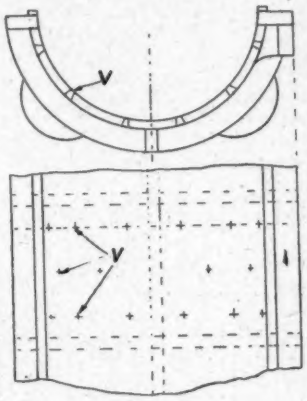


FIG. 9.

The face of the bottom portion of the mould and the first few inches at the bottom of the upper portion of the mould are formed of a stronger sand, a suitable one consisting of two barrows of open red sand, two barrows of old sand, one barrow of horse-dung and three large buckets of coal-dust, ground in the mill and passed through a ¼-in. mesh riddle.

Not a single vent is necessary if the moulds are thoroughly dry. The blacking used, with good results, consists of three-quarters of a bucket of mineral blacking, 1 gill of core-gum (mixed with boiling water), the whole mixed with water to a consistency suitable for application with a swab or mop. Although on certain jobs claywash is more suitable than core-gum, the amount of head removed from the liners prevents any of the bad effects, from excess of core-gum, from showing up in the casting, and the moulds are not so easily damaged with the necessary handling. A suitable metal for the liners described above has a composition as follows:—

	Per cent.		Per cent.
Total carbon	about 3 0		
Silicon	.. 1.5 to 2.0	Desirable	1.75
Sulphur	under 0.1	,,	0.05
Phosphorus	0.5	,,	0.1
Manganese	1.0	,,	1.0

Such an iron should not be difficult to produce using as the constituent brands hematite or Scotch, or both, with also some cheaper brand as Stanton or some other Derbyshire brand, also mild steel scrap (not basic steel). This scrap helps to keep the silicon and phosphorus down, by increasing the bulk of the metal with the addition of only a small amount of these elements. The effect of steel additions on the carbon and sulphur contents is uncertain and depends on several factors. The longer the steel remains in contact with carbon as coke after becoming hot, until actually tapped, the more carbon will be absorbed. This will also affect the sulphur content, the effect being increased if the coke is high in sulphur, the manganese contained in the metal determining the final effect of this sulphur on the metal.

Where an air furnace is available and the quantity of metal required warrants the extra expense of melting, its use is advantageous, as the carbon and sulphur are not increased by contact with the fuel and the question of admixture of charges intended for different purposes has not to be considered.

To improve the wearing qualities of the bore it is advisable to draw the core-barrels, as soon as the casting has solidified, by means of the crane. The boxes provided for this size of liner may of course be used for several sizes smaller, the one described in this article being the largest size made in the particular box.

CONTROL OF MINERAL AND METAL INDUSTRIES WITHIN THE BRITISH EMPIRE.—A recent issue of the Canadian Mining Institute Bulletin contains a short article on this subject by Mr. Trewartha-James, formerly general manager of the Tyee Copper Company, Ladysmith, British Columbia, who remarks upon the efforts made by the Germans during the few years preceding the war to acquire control of those metals, the importance of which in the manufacture of munitions was much more clearly recognised by them than by ourselves. The wolfram deposits of Burma and of Cornwall, for instance, were examined and studied with the greatest attention. "Speaking with one of the largest producers of wolfram in Cornwall not long since," writes Mr. Trewartha-James, "I was informed that he had sold all his wolfram to Germany from the first sample he produced. He contrasted strongly the terms offered by the German purchasing house with those of our own mineral brokers. The German house sent cash (in advance when required) on his own statement of the quantity that would be forthcoming. When they received the mineral, they sampled and weighed it quite fairly, and never penalised small excesses of cassiterite which it contained; on the contrary the Germans developed processes for the realisation of this valuable by-product, whilst English ore brokers strictly stipulated for severe and increasing penalties as the proportion of cassiterite increased. Our English methods and customs, which often have nothing but their antiquity to recommend them, are of such a mysterious and irritating nature that we lose a vast amount of trade from our unwillingness to adapt our methods to modern requirements. There is, no doubt, however, that the metallurgical establishments of South Wales and Liverpool are waking up."

Phosphor Bronze in Bridge Work.

The following notes are abstracted from a report of Sub-Committee C of the American Railway Engineering Association, dealing with the design, length and operation of turntables. The report deals with phosphor bronzes and the specifications accompanying the report are somewhat tentative. A test of the hardness of the bronze is provided for in the specifications. Hardness, as distinguished from compressive strength, is one of the primary qualities, but the experimental knowledge of the hardness numbers of bronzes is not yet great enough to warrant setting limits in the specifications as a criterion for acceptance. It is expected that systematic recording of the results of hardness tests on bronzes of the qualities here required will result in hardness limits which may be specified, perhaps to the exclusion of the compressive strength requirements.

Bronzes for Use in Turntables and Movable Bridges.

Bearing metals are used for the purpose of reducing friction and wear between parts of machinery in sliding contact. It is well known that the friction between surfaces of different metals is less than between surfaces of like metals. The same is true in a more marked degree of the tendency to heat and "seize" with motion under pressure. The simplest form of application of this principle of using different metals in contact is in the use of cast-iron bearings under rolled or forged wrought-iron or steel shafts. There is no tendency to heat and "seize" under moderate speeds; the friction is little, but, on account of the small difference between the metals, the wear is considerable, and the use of such bearings is limited to the crudest kind of machinery. Cast iron may then be said to be the primitive bearing metal.

In 1839 Isaac Babbitt discovered the alloy known as Babbitt's metal which has become a standard bearing metal for use in machinery the world over. The composition is shown in Item 1 in the accompanying table. On account of its high tin content, Babbitt metal is high in price and frequently is adulterated by the addition of lead. Many other white bearing metals have been made having tin and lead bases and marketed under various names, but all may be considered substitutes for Babbitt metal.

Bronze and brass come next in order of development of bearing metals. Being harder than Babbitt metal the friction and wear are less, but the fit of the bearings must be more nearly perfect.

The physical properties desired in bronze depend on the use to be made of it. For machinery bearings with low pressure and high speeds, under constant operation, the strength of the bronze is less important than its anti-friction and wearing qualities. For bearings of movable-bridge trunnions and discs, turntable discs, and similar slow-moving parts operated infrequently and carrying heavy pressure, the bronze must be hard enough and strong enough in compression to reduce friction to a minimum and not to flow or distort under the pressure. For worms, gears, nuts, etc., the bronze must have tenacity and hardness as well as anti-friction and wear-resisting qualities. The differentiation of bronzes according to the uses mentioned is a matter of recent years; the earlier practice was to use one kind for all purposes.

The hardness and strength of bronze increase with the amount of tin. The introduction of lead improves the wearing qualities and softens the metal, besides cheapening the product. Zinc increases the tensile strength but is injurious to the alloy for bearing purposes. It should not be used except in bronze for the third purpose mentioned above and then only in small quantities, as too much causes segregation of the tin and the formation of hard "tin spots."

Until 1887 the standard bearing alloy was seven parts copper and one part tin, shown as Item 2 in the table. Some time before 1887, Dicks, of England, patented the introduction of lead and phosphorus into the copper-tin alloy and the resulting metal became known as the "S Brand," Item 3 in the table. This alloy was adopted by the Pennsylvania Railroad and as a result of tests made by L. W. Cloud, Engineer of Tests, the specification shown in Item 4 was adopted. This probably was the first specification for phosphor bronze, and has been used widely and specified generally to this day.

About 1876, F. J. Clamer made and sold a metal known as Ajax metal, containing more lead and less copper than the "S" brand. This is shown as Item 5. It was used largely for engine bearings. Dr. C. B. Dudley, of the Pennsylvania Railroad, began a series of experiments and tests which proved the beneficial influence of phosphorus and lead in bronze. He then made experiments in the direction of increasing the lead and decreasing the tin which resulted in his "Ex B Metal," Items 6 and 63. Increasing the lead developed difficulties due to the fact that the lead does not alloy with the copper and tin but is mechanically held in the copper-tin alloy as a matrix. G. H. Clamer experimented with increasing amounts of lead and by decreasing the tin and using only pure metals produced successfully "Plastic Bronze," Item 7. This metal is suitable for light bearings and resists wear well but is too soft for bearings under heavy pressure.

Dr. Dudley made no experiments on the frictional effects of the lead. It appears that the introduction of lead decreases the wear but increases the friction. Experiments by Clamer show that while the wear decreases proportionately with the increase in lead the friction in the cases of lead exceeding 5 per cent. is as high as 40 per cent. greater than in cases having no lead. These results are said to have been confirmed by Spare in the Cornell laboratory. There are no definite experiments shown which show lead to improve the anti-frictional qualities.

The "S Metal" formula, Items 3 and 4, and the "Ex B Metal," Item 6, appear substantially in the specifications and recommendations of numerous engineers, Item 8 repeats the Dudley formula, Item 6, in slightly different form, and Items 9 to 23 inclusive are the "S Metal" formula with variations.

In Items 13 and 14 the elastic limit in compression 27,000 lbs., is too high to be attained with this composition, and the compression 1/16 in. under 100,000 lbs., is too small for this soft metal. Mr. Moore qualifies his recommendation in a way which subordinates the chemical composition to the physical requirements. An elastic limit in compression of from 15,000 to 20,000 lbs., and a per-

manent set of 0.25 in. maximum under 100,000 lbs., on a 1-in. cube seem to be consistent requirements with this composition.

The necessity for a harder bearing metal for heavy pressure has developed a series of formulas containing upwards of 20 per cent. tin and no lead. The metal produced has an elastic limit in compression of from 24,000 to 40,000 lbs., and the permanent set is from 1/16 to 1/10 in. Items 24 to 32 inclusive and 56 illustrate this class.

A considerable number of engineers believe in specifying the physical properties only and leave the chemical composition to the maker. Others modify this course by stipulating certain control over the formula but making the physical requirements the criterion for acceptance.

The third class of bronze, that requiring high tensile strength, is best secured by the introduction of from 1 to 2 per cent. of zinc. This constitutes gun-metal and examples are given in Items 49 to 58 inclusive. For this purpose the ultimate tensile strength and percentage of elongation seem to be more proper physical requirements than the compression characteristics.

There are two ways of introducing the phosphorus into the copper-tin alloy: first, by adding it direct to the molten metal; second, by the use of phosphor-tin for a part of the tin content. The first method is dangerous and results in the loss of a considerable part of the phosphorus. The second method gives better results and probably makes for more uniform crystallisation of the tin by the phosphorus. In the table those formulæ which contain phosphor-tin have the total tin content given in the tin column, the amount of phosphor-tin being given in addition. This permits of a more ready comparison.

So-called manganese-bronze being primarily a copper-zinc alloy, is not bronze but brass. The same is true of Tensilite bronze, Item 58. These alloys are designed for tensile strength and not for bearing metals, although they are so used. Manganese bronze is considered unsuitable for high pressure bearing purposes because of its fibrous structure.

Specifications.

(1.) Phosphor bronze shall be a homogeneous alloy of copper and tin of crystalline structure. It shall be made from new metals, except that scrap of known composition produced by the foundry at which the bronze is cast may be used. It shall not contain sulphur. The phosphorus shall be introduced in the form of phosphor-tin or phosphor-copper. Castings shall be sound, clean and free from blowholes, porous places, cracks and other defects.

(2.) The alloy shall be cast into ingots and allowed to cool, and the castings shall be poured from the remelted ingots. Care shall be exercised that the metal is not overheated and that the temperature at pouring and the conditions of cooling are such as will be most likely to secure dense castings.

(3.) There shall be four grades:—*Grade A* is to be used for contact with hardened steel discs under pressures exceeding 1,500 lbs. per sq. in., such as are used in turntables and centre-bearing swing bridges. *Grade B* is to be used for contact with soft steel at low speeds under pressures not exceeding 1,500 lbs. per sq. in., such as trunnions and journals of bascule and lift bridges. *Grade B* is to be used for contact with hardened steel discs under pressures exceeding 1,500 lbs. per sq. in. such as trunnions and journals of bascule and lift bridges. *Grade C* is to be used for ordinary machinery bearings. *Grade D* is to be used for gears, worm wheels, nuts and similar parts which are subjected to other than compressive stresses.

(4.) The chemical and physical qualities shall conform with the requirements in the following table:—

	Grade.			
	A	B	C	D
Copper per cent.	80 about	85 about	0abou	88 about
Tin per cent...	20 about	15 about	10 about	10 about
Lead per cent. .	—	—	10 about	—
Zinc per cent. .	—	—	—	2 about
Phosphorus per cent. ..	1.0 max.	1.0 max.	1.0 max. 1.7 min.	0.25 max.
Other elements, per cent. ..	0.5 max.	0.5 max.	0.5 max.	0.5 max.
Elastic limit in compression lbs. per sq. in.	25,000 min. 40,000 max.	19,000 min. 23,000 max.	15,000 min. 20,000 max.	14,000 min.
Permanent set under 100,000 lbs.	0.06 min. 0.10 max.	0.12 min. 0.25 max		
Yield point in tension, lbs. per sq. in. ..				To be Recorded
Ultimate strength in tension, lbs. per sq. in. ..				33,000
Elongation in 2 in. per cent. .				14

(5.) The chemical analysis of each heat shall be furnished.

(6.) Test specimens shall be made from coupons which are a part of the casting, and which have been fed and cooled under the same conditions as the casting.

(7.) Compression test specimens shall be cylinders 1 in. high and of 1 sq. in. area. The elastic limit in compression shall be the load which gives a permanent set of 0.001 in.

(8.) Tension test specimens shall be turned from a coupon not less than 1 in. in diameter. The diameter of the turned specimen shall be ½ in.

(9.) At least one compression test shall be made from each melt from Grades A, B and C; and one compression and one tension test for Grade D. For castings weighing over 100 lbs., finished, the prescribed tests shall be made for each casting.

(10.) The hardness of the finished castings shall be tested by the Brinell ball method and a record of the test furnished. The ball shall be of hardened steel 10 mm. in diameter. The load shall be 500 kg. and shall be applied for 30 seconds to a finished plane surface. At least two hardness tests shall be made upon each heat. A test shall be made on each trunnion bearing and each disc.

Uses of Bronze in Movable Bridges.

The following contribution to the Report is by C. E. Chase:—

In bridge work most of the uses of bronze are not really severe tests of bearing metals, in that the loads usually are determined by other considerations than the strength of the metal, and that the bearings are not used constantly enough in motion to make endurance to wear or heating difficult problems. Of the desirable qualities, it is first important that the friction be as little as possible. The ideal bearing metal is one containing a hard constituent to support the load and a soft constituent to act as a plastic support for the harder grains. In this case the yielding of the soft constituent will remedy irregularities of bearing.

For some uses the resistance to wear may decide between the various bronzes. Tests in the laboratory and in actual practice have shown that the

Bronzes ; Composition and Physical Properties.

Item No.	Kind or Source.	Copper.	Tin.	Lead.	Zinc.	Phosphorus.	Phosphor-Tin	Other Elements.	Elastic Limit Compression Pounds per sq. in.	Permanent Set Under 100,000 lbs. Inches.	Purpose and Remarks.
1	Babbitt Metal ..	3.7	89	—	—	—	—	S b. 7.3	—	—	Machinery bearings, low pressures, in general use.
2	Bearing Metal Used until 1887	87.5	12.5	—	—	—	—	—	—	—	—
3	"S" Brand ..	79	10	10	—	1	—	—	—	—	Patented by Dicks.
4	S Bearing Metal ..	78–80	9–11	8–11	—	0.7–1.0	—	—	—	—	Pennsylvania R. R. specifications.
5	Ajax Metal	77	11.5	11.5	—	—	—	—	—	—	Introduced by F. J. Clamer, 1876.
6	Ex. B Metal ..	77	8	15	—	0.25	—	—	—	—	Developed by C. B. Dudley.
7	Plastic Bronze ..	65	5	30	—	—	—	—	15,000 Ultimate	—	Ajax Metal Co., Developed by G. H. Clamer.
8	O. E. Hovey ..	76.8	8	15	—	0.2	—	—	—	—	Penna. R. R. experiments, 1892.
9	Waddell & Harrington	79.7	10	9.5	—	0.8	—	—	15,000	—	Information by O. E. Hovey.
10	Missouri Pacific Ry..	79.7	10	9.5	—	0.8	—	—	—	—	Information by C. E. Smith—for discs.
11	B. R. Leffler.. ..	79.7	10	9.5	—	0.8	—	—	—	.10	Suggested specification 1912.
12	N. Y. C. & St. L. R. R.	80	10	10	—	0.8	—	—	—	—	—
13	N.Y.N.H. & H.R.R. .	80	9.2	10	—	0.8	—	—	27,000	.0625	
14	W. H. Moore ..	80	10.5	9	—	0.5	—	—	27,000	.10 Trunnions; .0625 Disc.	"Provided this chemical composition gives the physical requirements."
15	E. S. Sperry ..	80	10	10	—	0.10	2	—	—	—	For bearings.
16	U.S. Engr. Dept ..	79.7	10 (9–11)	9.5 (8–11)	—	0.8 (0.7–1.0)	—	—	—	—	Specifications for Ohio River dams
17	U.S. Navy Dept. ..	78–81	(9–13)	8–11	Remainder.	(0.7–1.0)	—	Fe0.06 Max.	—	—	Specifications Grade 2.
18	J. E. Greiner ..	79.7	(9–11)	8–11	—	(0.7–1.0)	—	—	15,000 20,000	—	SpecificationsHanover St. Bridge. For bushings of journals and shaft bearings.
19	85 ft. Turntable at Syracuse	79	10	10	—	1	—	—	23,500	.30	14 in. disc removed after 4 months because too soft.
20	Transfer Bridge No. 1	79.5	10.9	9.1	0.5	—	—	—	19,500	.30	For worm gear rings and nuts for hoisting screws.
21	City of Chicago ..	80	10	10	—	Quantum Suf.	—	—	15,000 Min.	.25	Specifications for trunnion bascule bridges.
22	Lead Bronze ..	80	10	8–11	—	1.0 Max.	—	0.5 Max.	15,000 20,000	—	Proposed by Clement E. Chase for low pressures and high speeds.
23	Scherzer Rolling Lift Bridge Co.	80	10	10	—	0.8	10	—	18,000	—	—
24	C. C. Schneider ..	80	20	—	—	0.2	5	—	24,000	—	Elastic limit given is per former specifications.
25	Ajax Metal Co., ..	85	15	—	—	—	—	—	—	.0625	Suggested to meet the ¼ in. specification.
26	Strauss Bascule Bridge Co.	85	14.2	—	—	0.8	—	—	22,000	10	Specifications for one bridge, 1915.
27	85 ft. Turntable at West Albany	85	15.0	—	—	0.8	—	—	40,000	.074	—
28	85 ft. Turntable C C C. & St. L. Ry. ..	79.2	19.8	Trace	0.1	32	—	—	—	—	—
29	Transfer Bridges 3 and 4	84.8	12.8	0.3	0.6	0.83	—	—	25,000	174	Bushings for pins supporting girders.
30	Transfer Bridges 3 and 4	84.8	13.3	0.03	1.0	0.43	—	—	23,500	25	Worm gear rings and nuts for hoisting screws.
31	British Admiralty ..	90	9.7	—	—	0.3	—	—	—	—	—
32	85 ft. Turntable C.C.C. & St. L. Ry.	77.1	21.3	Trace	1.3	—	—	—	—	—	—
33	High Tin Bronze ..	—	—	—	—	1.0 Max.	—	0.5 Max.	22,000 27,000	.06–.18	Proposed by Clement E. Chase for high pressures and low speeds.
34	Medium Tin Bronze .	—	—	—	—	1.0 Max	—	0.5 Max	19,000 23,000	.12–.25	Proposed by Clement E. Chase for high pressures and low speeds.
35	Gun metal	88	10	—	2	—	—	—	—	—	Designated as gun metal by C. E. Chase. Recommended for gears and worms.
36	U.S. Navy Dept. ..	85–90	6–11	0.2 Max.	Remainder.	0.3 Max.	—	Fe. 0.06 Max.	—	—	Specifications Grade 1.
37	Isthmian Canal Com.	87–87.25	10.9–11.0	0.15–0.20	1.65–1.85	—	—	—	—	—	Specifications for worm wheel rims.
38	American Bridge Co.	89.5	10	—	—	—	—	S b.0.5	15,000	—	For worm wheel rims. Copper to be 81.5 Pig. Cu. + 8.0 Manganese Cu.
39	R. W. Hunt & Co. .	80	18	—	2	—	—	—	—	—	Good mixture for wheel castings.
40	St. Louis S.W. Rly.	84.14	10–13	2.60	1.07	0.24	—	Fe. 2.24	—	—	Castings for White River draw span. Iron indicates scrap.
41	E. S. Sperry ..	90	10	—	—	0.05	1	—	—	—	For the highest possible strength.
42	Gun metal ..	88	10	—	1.75–2.25	1.0 Max.	—	0.5 Max.	—	—	Proposed by Clement E. Chase for gears and worms ultimate tensile strength 35,000 lbs. minimum.
43	Tensilite Bronze ..	67.0	—	—	24.0	0.01	—	Mn. 3.8 Al. 4.4.	60,000	.0133	85 ft. Turntable at W. Albany. Installed 1913. This is brass, not bronze.
44	Penna. R. R Experiments	76.8	8	15	—	0.2	—	—	—	—	Journal Franklin Institute Feb. and March, 1892.
45	Manganese Bronze .	56–57	1	—	38–40	—	—	Fe.1.5	35,000 40,000	—	Average qualities given C. E. Spare.

softer bronzes wear less and that the bronzes with lead content are superior in this regard to those without, and that this advantage increases with the proportion of lead. A certain amount of strength in compression, to resist pressure without flowing, is required. Computed unit stresses, however, usually are low, as they commonly are fixed in the case of trunnions or journal bearings by the amount that will allow the maintenance of an oil film between rotating part and bearing.

Uniformity of structure and freedom from oxides are necessary features of good bronzes. Fineness of microstructure is important in that it is found to accompany high physical properties and has an important effect on the wear of both the bearing and the rotating part. Considering the agency of wear as the dislodging of the hard particles from the soft matrix, it is seen to be an advantage that these particles be as small as possible.

These are the four following distinct classes of duty for bronze in connection with movable bridges :—

(1) For centre-bearing discs or drawspans, working between surfaces of hardened steel at low speed and under heavy pressures of from 3,000 to 3,500 lbs. per sq. in. When used in this way there is a chance of poor lubrication due to the oil film being squeezed out during the periods of rest. To reduce the friction of turning and meet the unit pressures, a hard bronze is necessary. Wear is not an item of importance, as the number of revolutions during the lifetime of a bridge never causes appreciable wear. Centre-bearing discs are commonly used against hardened, or at least high-carbon, steel surfaces, so that the hardness of the bronze usually need not be limited by fear of abrasion. The lenticular shape of the discs and the manner in which the load is applied make the risk from brittleness a minimum. The use of phosphorus in the bronze aids in securing both hardness and freedom from oxides.

An extremely hard bronze usually is specified, the requirement for elastic limit in compression being a minimum of 24,000 or 27,000 lbs. per sq. in., with a set under 100,000 lbs. per sq. in. of not over 1/10 inch. Too-steel bearing surfaces, often oil-hardened, are commonly used with this bronze. The foundry must make a bronze with tin content about 20 per cent. and phosphorus 0.8 to 1.2 per cent. to meet this specification, which places no limit on hardness. The result is an extremely brittle material that must be handled with every precaution. Test results on bronze made to this specification frequently show elastic limits of from 30,000 to 40,000 lbs. per sq. in. in compression. The bearing surfaces are very apt to warp slightly in hardening after being machined and it then becomes a very difficult matter to secure uniform bearing on the disc. The writer believes that a somewhat softer bronze, with tin content about 16 to 18 per cent. (elastic limit about 20,000 or 24,000 lbs. per sq. in.) working between high-carbon (not hardened) steel bearing surfaces, would be found equally satisfactory in service.

(2) For trunnion bearings carrying medium or structural steel trunnions at low speed under moderate computed pressures, usually from 1,500 to 2,000 lbs. per sq. in. These unit pressures, computed on the projected area of the trunnion, are limited to these amounts by considerations of lubrication. A hard bronze is desirable for two reasons: First, during periods of rest the oil film may be squeezed out and then a hard bronze is advantageous, as friction will be less and the chance of gripping of the trunnion less. Friction is important, as the power consumed in opening and shutting the bridge will depend largely on it. Second, it is entirely probable that the actual unit pressures in the surface of contact between trunnion and bearing are for a long time, possibly always, considerably in excess of those computed. Wear is not important in this case. Trunnions are commonly of structural-grade steel, and B. R. Leffler refers to two cases in which shafts, where a very hard bronze was used, became abraded. The possibility of unevenness of the support of the bushing, its comparative thinness and the chance of shock make the question of brittleness rather important.

While phosphor bronzes of the hard type (copper 80-82 per cent., tin 20-18 per cent.) have been used frequently in trunnion bearings, as also has been the standard lead bronze (copper 80, tin 10, lead 10 per cent.), the medium bronze recommended by Mercer and incorporated in Leffler's specifications, seems for many reasons best. The physical qualities can be met with a bronze of about 14 per cent. tin content.

(3) For shaft bearings working under light loads at high speeds. In this case wear is a matter of first importance, as it usually is a matter of great difficulty and expense to replace the bushings of an important bearing in the machinery of a movable bridge. This makes a fairly soft lead bronze desirable. Lubrication usually can be counted on to be continuous, and the pressures hardly are great enough to make it likely that the shaft would be gripped even if the bearing ran dry for a short time. The tin content should be comparatively low, because it then is easier to have the lead uniformly distributed throughout the casting. For uniformity and freedom from oxides which may cause heating, phosphor bronze should be used.

The " standard " lead phosphor bronze (copper 80, tin 10, lead 10 per cent.) is used commonly and probably is as well adapted as any other to the purpose. Specifications should not call for physical properties incompatible with these proportions.

(4) For gears and worms, requiring resistance to both tension and wear. The composition must be hard so as not to flow, but not so hard that the pinion or gear that is engaged will become abraded, nor brittle, as shock is very likely to occur. High tensile strength, ductility and denseness are prime requisites.

A lead bronze is unsuitable, being too soft and uncertain in tension. Probably there is nothing better for this use, where its strength is sufficient, than the venerable gunmetal formula, copper 88, tin 10, zinc 2 per cent. Phosphorus does not seem necessary with the zinc present, and some authorities assert that the bronze is injured by the presence of both.

THE CORROSION RESISTANCE OF COPPER STEEL.—Recent tests made in order to obtain definite information as to the influence of the presence of varying amounts of copper and other elements, when alloyed with steel, on the corrodibility of the latter have led to the following conclusions :—(1) Copper increases the resistance of steel and iron to atmospheric corrosion. Its influence is apparent when the copper content reaches only 0.03 per cent. Its effect is almost at a maximum when the copper reaches 0.05 per cent., and the best amount of copper for commercial steel has been found to be 0.25 per cent. (2) Steel containing 0.25 per cent. copper outlasts " pure iron " containing 0.04 per cent. copper. (3) Steel containing 0.05 per cent. copper lasts as long as " pure iron " containing 0.04 per cent. copper. (4) Sulphur in steel accelerates corrosion very markedly. (5) Sulphur oxides in the air accelerate the corrosion of steel. (6) Copper in steel counteracts or retards both the corroding influences noted in 4 and 5.

American Foundrymen's Convention.

The annual meeting of the American Foundrymen's Association and the American Institute of Metals will be held in Cleveland, Ohio, during the week commencing September 11 next. Separate sessions will be held for the discussion of topics relating to the manufacture of grey iron, steel and malleable cast iron. The opening meeting will be held at the Hotel Statler, on September 11, in the afternoon, and will be followed by morning sessions only, the convention closing on Friday, September 15.

The following papers are included in the programme:—

"Sand Reclamation," by H. B. Swan.

"Progress Report on Sand Reclamation," by C. P. Karr (Associate Physicist, U.S. Bureau of Standards).

Symposium on "The Results of Closer Co-operation Between the Engineer and the Foundry," as relating to:—"Grey Iron," by D. W. Sowers; "Steel," by J. H. Hall; "Malleable Iron"; "Non-Ferrous Metals," by C. E. Chase.

Symposium of "The Influence of Gating on Castings," including:—"Grey Iron," by B. D. Fuller; "Steel," by W. Gilmore; "Malleable Iron," by A. M. Fulton; "Non-Ferrous Metals," by R. R. Clarke.

"The Significance of the Fire Waste," by H. Wentworth.

"Profit Sharing in the Jobbing Foundry," by C. E. Knoeppel.

"What the Pratt Institute Has Done, Is Doing and Hopes to Do, in the Training of Men for the Foundry Industry," by S. S. Edmands.

"The Installation of Uniform Cost Systems by Members of Technical Societies," by C. H. Scovell.

"Report of the Committee on Foundry Costs," by B. D. Fuller.

"Report of the Committee Advisory to the U.S. Bureau of Standards," by Richard Moldenke.

"Report of the Committee on Safety and Sanitation," by Victor T. Noonan.

"Report of Representatives on the Conference Board on Training of Apprentices," by B. D. Fuller.

"The Effect of Different Mixtures on the Strength of Chilled Car Wheels," by G. S. Evans.

"The Manufacture of Semi-Steel Castings," by David McLain.

"The Use of By-Product Coke in Foundry Operations," by G. Long.

"How Certain Cleaning Room Problems Have Been Solved," by H. Cole Estep.

"The Use of Borings in Cupola Operations," by James A. Murphy.

"One-Third of a Century in a Grey Iron Foundry," by A. E. Howell.

"The Introduction of Molding Machines in Foundries," by A. O. Backert.

"The Experimental Foundry," by H. K. Hathaway.

"Report of Committee on Standard Methods for Coke Analysis," by H. E. Diller.

"Report of Committee on Standard Specification for Foundry Scrap," by G. E. Jones.

"Report of Committee on Standard Specifications for Grey Iron Castings," by W. P. Putnam.

Symposium on "Electric Furnace Practice for the Manufacture of Steel Castings," including contributions by: F. T. Snyder, A. B. Clarke, John A. Crowley.

"Making Electric Steel in the Rennerfelt Flaming Arc Furnace for Foundry Purposes," by C. H. Vom Baur.

"Crucible and Electric Steel Compared," by T. S. Quinn.

"Converter and Electric Steel for Casting Purposes, Compared," by P. Blackwood.

"Manganese Steel Castings," by W. S. McKee.

"Titanium in Steel Castings," by W. A. Janssen.

"Report of Committee on Steel Foundry Standards," by D. Shoemaker.

"Report of Committee on Specifications for Steel Castings," by J. H. Hall.

"The Small Open-Hearth as a Flexible Unit for Either Large Steel Foundries or General Jobbing Shops," by F. Carter.

"The Presence of Alumina in Steel," by G. F. Comstock.

"The Particular Application of Green-Sand Molding in the Steel Foundry," by A. F. S. Blackwood.

"Theory and Practice of Heading and Gating Steel Castings," by R. H. West.

"Acid versus Basic Steel for Making Castings," by E. F. Cone.

"Alloy Steel Castings," by D. Evans.

"The Application of Malleable Iron Castings in Car Construction," by F. J. Lanahan.

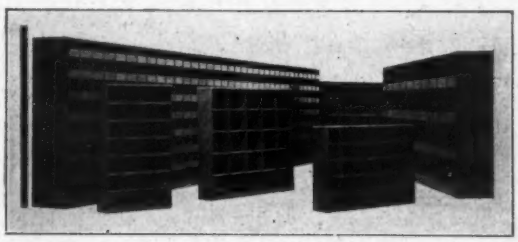
"Commercial Side of the Malleable Iron Industry," by W. G. Kranz.

"Report of Committee on Specifications for Malleable Iron Castings," by Enrique Touceda.

As in previous years, concurrent with the Convention will be held an exhibition of foundry equipment and accessories, while also an interesting programme of visits and entertainments is being arranged.

Steel Bins for Works.

At the present time when extensions are numerous and there is a scarcity of both materials and labour, the provision of bins and cupboards for workshops, stores, and other departments of factories and warehouses, forms a problem not always easy of solution. Messrs. Joseph Sankey & Sons, Limited, however, are making at the Castle Works, Hadley, Salop, a wide range of stamped



steel bins, which besides being easily and quickly fitted up, combine the several qualifications of efficiency, cleanliness and durability. These bins cover a large field of usefulness, and almost any reasonable size or quantity can be supplied. A few of the regular series are illustrated here. For those engineering and allied trades where the work is rough and heavy these steel bins are specially suitable. Another very useful appliance is the Sankey steel cupboard, which the firm are making in considerable quantities for holding the workers' clothes and tools.

ORDERS have been made by the Board of Trade requiring the undermentioned businesses to be wound up:—Balcke & Company, Limited, Broadway Court, Broadway, London, S.W., water-cooling apparatus. Controller: J. W. Barrett, 19a, Coleman Street, London, E.C. July 13, 1916.—F. M. Frye & Company, 46, Upper Thames Street, London, E.C., hardware merchants and tool makers and merchants. Controller: Charles William Middleton Kemp, 36, Walbrook, London, E.C. July 24, 1916.—M. C. Wedekind & Company, Limited, 6, Lloyd's Avenue, London, E.C. Dealers in old iron and steel. Controller Frank H. Finlaison, 46, London Wall, London, E.C. July 20, 1916.

"F.T.J." Bookshelf.

Discovery.—By R. A. GREGORY. (London: Macmillan & Company, Limited, St. Martin's Street.—Price, 5s. net.)

In this interesting book is given a general chatty discourse on the spirit and service of science. The position of science in the State, its relation to industry, and its relative neglect in education, have prompted the author of the work to an effort to promote a more sympathetic attitude towards those who are engaged in the pursuit of scientific truth. In the copious quotations from different writers and the many recollections and anecdotes of eminent men of science is presented a mass of testimony to the greatness and value of scientific research. The book is more than a mere record of attainments; it not only shows the relation between the search for truth in the past and our present state of progress, but also points out the inseparable connection between scientific endeavour in all fields and the continued well-being of the race in every sense, whether physical, mental or spiritual. The book should go far to remove the widespread misconception which prevails as to the meaning and influence of science, and if the author is severe in regard to national and governmental parsimony in the matter of scientific research, the severity has been fully merited.

Heat-treatment of Tool Steel.—By HARRY BREARLEY. (London: Longmans, Green & Company, 39, Paternoster Row, E.C.—Price, 10s. 6d. net.)

The author of this book is sufficiently well-known as an authority on steel, for any volume from his pen to receive serious attention. The volume before us—"an illustrated description of the physical changes and properties induced in tool steel by heating and cooling operations"—is a second (revised) edition of the book which he presented in 1911, for the use of artisans and foremen engaged in the work. Steel-making operations are discussed to somewhat greater length than formerly, while alloy steels generally and high-speed steels in particular are more fully dealt with; and a good deal of really practical information is given. The chapters on the hardening of steel, tempering and straightening, and defective tools evince intimate acquaintance with works' practice, and embody much useful information. Perhaps the book on the whole is rather too obviously a discussion from the laboratory standpoint. Nevertheless, the importance of scientific control in such work as the heat-treatment of tool steel is sufficient to justify full insistence on the laboratory aspect of the subject, particularly when presented by one who is certainly very familiar with the practical side. The book is certainly worth careful study by all those connected with this branch of industry.

The Physico-Chemical Properties of Steel.—By C. A. EDWARDS, D.Sc. (London: Charles Griffin & Company, Limited, Exeter Street, Strand—Price, 10s. 6d.)

The object of Professor Edward's excellent book is to give an account of the chemical and structural constitution of steel, to describe the internal changes that occur when steels are heated and cooled under varying conditions, and to indicate the effects of those changes upon the properties of the materials. It need hardly be said that anything which comes from the pen of Professor Edwards is likely to be authoritative in statement, and in the present work he has very ably gathered together a large number of facts dealing with the subject matter of the volume. Considerable attention is given to the thermal and structural transformations of the iron-carbon system, which is dealt with from the point of view of the equilibrium diagram. The book, which extends to something over 200 pages, collects together most of the important facts dealing with the metallography of steel in a form which will be found most useful to the layman. Special chapters are devoted to burning and overheating, cementation and case hardening, and the various special and alloy steels.

Trade as a Science.—By ERNEST J. P. BENN. (London: Jarrold & Sons.—Price, 2s. 6d.)

This is an interesting little volume, the author being a well-known London trade journalist. He deals with a number of very interesting business topics, particularly on the lines of suggesting greater co-operation between manufacturers for the home and export trade. In the author's view, the present trading conditions of this country are in chaos, and involve considerable danger, and with this we think many business men will agree. The author has a very informing chapter on what he calls "A Model Trade Association," and he also gives an outline of a suggested scheme for a Ministry of Commerce, with six Under-Secretaries, who are to deal with:—(*a*) Export. (*b*) Industrial and scientific research. (*c*) Commercial education. (*d*) Statistical and financial. (*e*) Labour. (*f*) Exhibitions and advertising. An interesting introduction to the volume is written by Lord Burnham, who points out that the question, "What is to be the future of British trade after the war?" is one which is often asked but which has never yet been answered, except in part. Mr. Benn's little book seeks to supply some of the weak links in the business chain which has been so near snapping-point in many industries.

Queries.

Acid Resisting Castings.

Can you give us any information as to how to produce acid-resisting castings? Who are the original people who issue licences under the patents, etc.?—"T. W. W."

Reply.

We believe that most of the proprietary acid-resisting castings processes depend on the art of casting very high silicon irons, and the firms producing them have developed their practice by means of extensive experiment and the study of moulding requirements and considerations of design. Shrinkage, cracking and other defects are a source of prolific trouble when dealing with very high silicon irons, and the foundry requires to specially develop its practice for the work and train the men for it also. Some of the makers of these castings have been through troublesome and expensive experience before attaining success, and we should not advise founders to embark on the venture unless they are prepared to buy similar experience. There may be inventors of special processes and compositions who are prepared to impart information and grant working licences, but we do not know of any such. Perhaps some of our readers can assist on this point.

Defective Cylinder Castings.

(*Reply to query in June issue.*)

In the first place, "Gala" does not say if it is dirt or a draw which he considers the cause of the defects. However, as I have made a few hundred of similar cylinders with no defects at the point which gives him trouble, I would advise him to change his way of running, as I have always found when running from the bottom that the top inlet or gate always allowed more dirt than when run wholly from the bottom. I was very successful when running from the top with four small gates dropped down the barrel. The head was carried up the same diameter as the flange, which gave plenty for feeding pressure and always left a clean flange when cut off. The mixture was similar, as both Shotts 4 and Carron 4 were very much in use in the shop. The riser I consider of no value for feeding.—"T. B."

The Danforth Open-Hearth Chequerwork.

From particulars recently published in the American technical Press,* it appears that what is claimed to be a substantial improvement in the construction of chequerwork for open-hearth furnaces has been introduced by Mr. George L. Danforth, jun., manager of the open-hearth department of the South Chicago plant of the Illinois Steel Company, where it has been in operation on all the open-hearth furnaces for approximately the past eighteen months, and, operating with a metal charge of 68 per cent. of iron, 24 per cent. of steel scrap, and 8 per cent. of metal from iron

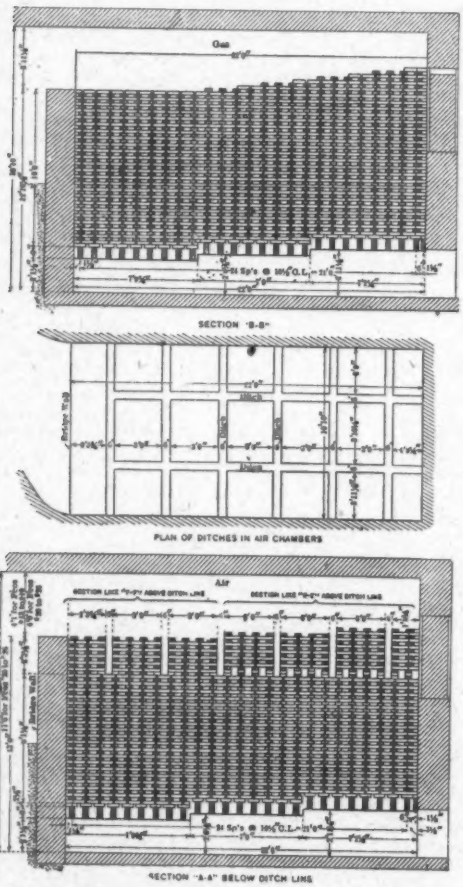


FIG. 1.—CROSS-SECTION LONGITUDINAL DIAGRAMS OF DANFORTH CHEQUER CONSTRUCTION.

ore, etc., has produced a tonnage never before obtained on furnaces of equal size.

The principle aimed at in the new form of construction is to provide in the generating chambers an arrangement of the brickwork that will maintain to the highest possible efficiency the four main features that are essential for the fast and economical operation of heating or melting furnaces. These features are:—(1) To contain in the chambers a mass or number of bricks as great as possible to afford a maximum storage capacity for the heat units to be taken from the outgoing hot waste gases, to be later transferred to the incoming air or gases. (2) To give the brickwork a maximum surface, exposed in such a way that the air and gases come into intimate contact with the brickwork, in order to facilitate the rapid transfer of the heat to and from the provided storage. (3) To provide passageways or flues through the brickwork sufficiently large for the passage of the air and gases, yet not so large that the hot outgoing gases might pass through one part of the chequerwork and the incoming cold air or gases through another part. (4) To provide a structure of the brickwork best adapted for the three foregoing features, yet so stable in construction that there will be avoided the frequent trouble of the brickwork collapsing when heated to a high temperature.

A correct combination for the first three features would not be so difficult if the passageways or flues would remain clean and retain their original area, and, also, if the relatively thin bricks necessary to provide the maximum exposed surface when laid on their edges, as is commonly done, did not present an insufficient bearing for the adjacent bricks, resulting in an unstable construction. If the flues when first installed are made large enough to avoid loss of furnace draft, it must be done at a sacrifice of brick mass and exposed surface, and the passageways are then too large when the furnace is first put into operation, and allow the outgoing hot gases to channel and escape without coming into contact with sufficient brick mass and surface to afford proper regeneration for the incoming cold air and gases.

In the Danforth construction, as shown in the illustrations, there are provided in the upper part of the chequerwork channels or ditches through which the gases will to a gradually increasing extent by-pass the original or ordinary entrances that become obstructed by the deposit, and enter the vertical flues by the side entrances at a lower elevation, providing additional entrances to the chequerwork. It is therefore possible to retain the maximum amount of brickwork with the smaller flues without sacrificing the furnace draft. By laying the bricks on their flat side, instead of on edge as in ordinary practice, there is obtained a large base of contact with the adjacent bricks and a lower centre of gravity for each brick, resulting in a stable construction.

The cost of installing this improved chequerwork is practically the same as that of other commonly-known constructions; while the cost of maintaining or renewing it is slightly greater than some and less than that of others; but inasmuch as the cost of installing, maintaining or renewing the chequerwork is approximately 1 per cent. of the open-hearth ingot conversion cost, which can be increased 10 per cent. with a poor working furnace, and decreased 10 per cent. with a fast hot-working furnace, the chequerwork cost of itself is immaterial.

It is claimed that with this chequerwork the average production of an open-hearth furnace can be increased by at least 12½ per cent. Inasmuch as the installation cost in dollars of an open-hearth plant, with its auxiliaries, is approximately five times the annual capacity, and the average conversion cost of ingots in the States is about $3.50 (14s.) per ton, this installation, on a furnace having with ordinary chequerwork an annual production of 45,000 tons, would produce an additional 5,625 tons, which, multiplied by five, would otherwise

* "The Iron Age."

cost $28,125 (£5,800) to build; and furthermore, would each year save $17,718 (£3,544) by a 10 per cent. reduction in the conversion cost of 50,625 tons of ingots.

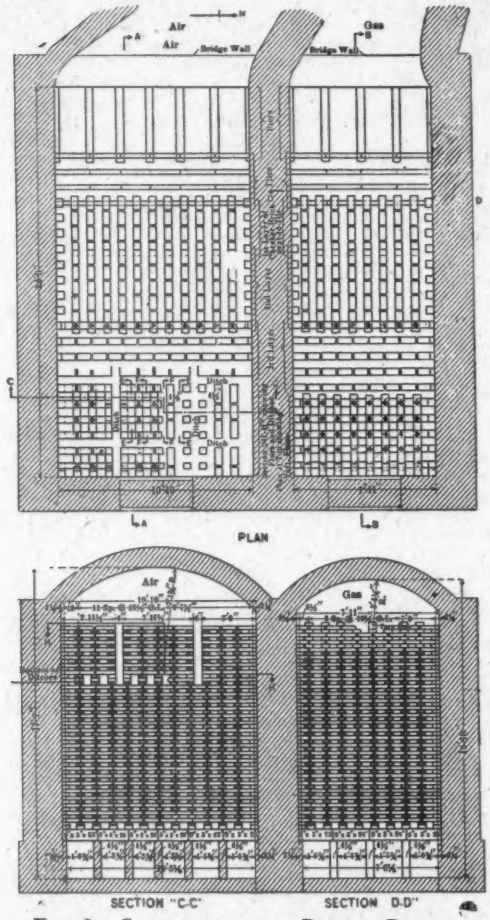


FIG. 2.—CROSS-SECTION AND PLAN OF DANFORTH CHEQUER CONSTRUCTION IN REGENERATIVE CHAMBERS.

Table I. shows the comparative average production of furnaces with and without the Danforth chequerwork :—

TABLE I.

	Tons per 12-hr. turn.	Tons per 12-turn week.	Tons per week per sq. ft. of hearth area.
Normal production of 50-ton furnaces	68.2	818	2.09
Normal production of 75-ton furnaces	84.4	1,013	1.73
Fourteen 50-ton furnaces at South Chicago with ordinary chequers	75.6	907	2.32
Same fourteen 50-ton furnaces producing 805,000 tons after being equipped with the Danforth chequerwork	92.1	1,105	2.83

The Knox Pressed and Welded Steel Company has acquired the selling rights of this improvement.

Alloys for Water-Conveying Plant.

Writing in the "Journal of the American Waterworks Association," Mr. H.Carpenter remarked that alloys for water-conveying plant are used in two forms :—(1) Castings of various parts, where the material passes direct from foundry to point of application, with only such manufacture as tends in no way to alter the structure of the material or change its physical characteristics. (2) Bars and tubes, whose structure and physical characteristics are changed after leaving the foundry, by the processes of forging, rolling, extruding or drawing.

He continued :—The ideal alloy should have the three following characteristics :—

(1) It must be able to withstand, for an indefinite period, the disintegrating action of the elements, in the form of corrosion, erosion or electrolysis.

(2) It must be able to withstand disintegration due to the failure of its component parts to retain their original relation one to another, and must be free from internal stress, which will produce progressive failure. The latter requirement implies a composition capable of successful manufacture under existing commercial conditions.

(3) The physical characteristics should be as high as practicable so that the desired result may be obtained at least expense.

Four classes of alloys may be considered as to their ability to fulfil these requirements. They are the bronzes, the brasses, copper-nickel alloys and nickel-steel alloys.

Considering first the most commonly used bronze composition, 88-10-2 or naval bronze, castings of this alloy are non-corrosive in the presence of nearly, if not all, the elements with which they are ordinarily brought in contact; they are easily obtainable, of a homogeneous character under ordinary commercial conditions, are stable and constant in physical characteristics, and the material is one that works well in the ordinary machinery operations. Their physical characteristics are sufficiently high for the apparatus not to need to be unwieldy or unduly heavy in design to obtain the requisite strength under any ordinary conditions. The alloys must be used for castings only, as their high tin content makes it impossible to hammer, forge, roll or draw them successfully, so that where rods or tubes are required the content of tin must not exceed 2 per cent., and most manufacturers hold to a maximum of 1¼ per cent.

Where conditions of design require greater physical characteristics than shown by the bronzes, or where forged, rolled or drawn forms are required, resort is made to the brasses. For castings of this character, manganese bronze has been very generally accepted and has given very satisfactory service. A characteristic casting of this material shows a composition of about 56 per cent. copper, 40 per cent. zinc, 1 per cent. tin, 1.27 per cent. iron, and 1.8 per cent. manganese. The manganese content is small, and the analysis of the casting need not show any, the manganese being introduced in the form of the ferrous-oxide to act as a flux; but the residue in the casting should not exceed 2 per cent. Certain manufacturers use vanadium in the place of manganese, and the resulting castings are of the same general character as manganese bronze.

Forgings, rods and bars of these alloys show very satisfactory non-corrosive properties and physical characteristics considerably greater than the cast material.

D

Non-Ferrous Notes.

Bronze for Contact with Lime and Water.—An alloy which has been recommended for castings in contact with lime and water is:—90 per cent. copper and 10 per cent. tin, the working proportions being copper 89.75 per cent., tin 10 per cent., and phosphor-copper 0.25 per cent. The phosphor-copper should be added to the copper when the latter is melted, and the tin then introduced.

Burning in of Cores.—The following method of overcoming the trouble of cores burning in is recommended by "The Metal Record":—"A good way is to mix fireclay and molasses water, adding to the strained portion red talc to the consistency of thin batter. Paint the cores uniformly with this mixture, and dry them slowly so as to prevent surface cracking. This makes a highly refractory and smooth surface protection, which has the advantage of lower cost as compared with the use of plumbago."

Cerium.—This element (chemical symbol Ce.) is found in a few rare minerals—cerite and orthite—along with similar elements, and silica. It is prepared by the electrolysis of its chloride as a steel-grey lustrous metal. The melting point of the metal is 640 deg. C. (1,184 deg. F.) or a trifle higher than the melting point of antimony, the specific gravity is 6.92, and the hardness is about equivalent to that of tin. The metal may be readily rolled into sheets or drawn into wire, but its chief application is as an oxide, and in the manufacture of incandescent gas mantles.

Phosphorus and Pin Holes in Brass Castings.—When pin holes occur in brass castings into which phosphorus has been introduced they may result from excess of the latter constituent. When zinc is present in a mixture, very little phosphor-tin or phosphor-copper can be used. An ounce or two to 100 lbs. of metal is all that can safely be employed. When no zinc is used in a mixture a much larger quantity of these phosphorus alloys can be employed, as is well seen in phosphorised gun-metal, in which the phosphorus is often present in considerably greater proportions.

Carbon Influence in Nickel Silver.—The presence of carbon in nickel silver or "German" silver often causes trouble if the metal is destined for rolling. The carbon may be absorbed from the crucible during melting, resulting in the condition known as "hard." Nickel, when melted in contact with carbon, absorbs the latter the same as iron, and a malleable, ductile nickel can thus be converted at one melt to a brittle metal. The addition of metallic calcium has been suggested as a means to correct the difficulty, about 1 per cent. of a 10 per cent. calcium-copper alloy being the addition recommended.

Black Coating on Zinc.—To obtain a durable, black coating on metallic zinc the use of nitrate of manganese has been advocated. A solution containing 2 oz. of nitrate of manganese in 1 gal. of water is applied to the zinc, the surface of which is cleaned and warmed so as to dry off. The non-adherent oxide is then wiped off and the operation repeated. Six or seven treatments are said to be necessary in order to produce the desired results. When finally completed, the surface is rubbed over with linseed oil. The coating of peroxide of manganese so formed strongly adheres to the zinc and resists the action of acids, and it is not poisonous.

Boron in Sterling Silver Alloy.—A sterling silver alloy containing boron, patented by E. D. Gleason (U.S.A.), is composed of 92.5 per cent. of silver and 7.5 per cent. of "boronised" copper. The latter is made in the following manner:—Copper is heated with boron fluoride while in the molten condition, and the boron unites with the copper forming the boronised product. The copper and boron alloy thus obtained is used in making the sterling silver by melting it with fine silver. The sterling silver thus made with boron is claimed to be much harder than the ordinary alloy. It is also stated that the sterling silver thus made may be readily cast in sand without honeycomb defects.

Silundum.—This material, first produced a few years ago, is a product of the electric furnace. It is obtained by heating carbon with carborundum, to which sand may also be added. The product is intermediate between carbon and carborundum. The temperature used for heating is from 1,700 to 1,800 deg. C. Carbon articles can be converted by this treatment into silundum on one or both sides. The electrical conductivity of silundum is considerably less than that of carbon. It is stable in the air up to high temperatures. Molten metals, such as iron, rapidly destroy it, and consequently articles like crucibles should be converted into silundum only on the outside. The chief use suggested for the material was as a permanent resistance material for high-temperature work.

Zinc in Steam Metal.—The composition of "steam metal" usually varies within the limits:—Copper, 84 to 90 per cent.; tin, 6 to 10 per cent.; zinc, 2 to 8 per cent.; lead, 1 to 4 per cent. The question of how much zinc is permissible for good work, however, has troubled many founders. Generally, the zinc content should not be less than 2 per cent., but should not be more than 4 per cent., owing to the dross or zinc oxide which forms on the face of the molten metal. A mixture with an excess of zinc does not usually produce such sound castings, able to withstand pressure, as a mixture with less zinc. Leakage of valves under test can often be traced to the presence of too much zinc in the metal, though excess of lead may give similar trouble, and, therefore, the latter metal should be kept as low as possible compatible with good machining qualities.

Strong White Alloy for Fittings.—In our issue of June last was mentioned a strong white alloy used for boat fittings and similar work, the composition of which is 50 per cent. copper, 35 per cent. zinc, 15 per cent. nickel, with 0.1 per cent. aluminium added to aid casting. The procedure in making this alloy is to first make an aluminium-zinc alloy of 1 to 19 parts and pour it into bars for breaking up; then use for the final mixture the following:—Copper, 50 per cent.; zinc, 33 per cent.; nickel, 15 per cent.; Al.-Cu. alloy, 2 per cent. The copper and nickel (the high melting-point metals) are first melted together, then the Al.-Cu. alloy introduced, and the zinc added last. The advantage of this procedure lies in the accurate control of the aluminium content, for the mixture is considerably affected by an excess. If the mixture is re-melted before pouring into castings, about 1.5 per cent. of zinc must be added to compensate for loss of zinc, and this applies at every re-melt.

Cores for Cast Aluminium.—The first essentials in a core for casting aluminium are porosity and low resistance to the shrinkage of the metal in cooling. Iron and even brass core-making practice must be disregarded, and the cores be made especially for aluminium. The sand should not be very fine, unless extreme fineness of finish in the cored parts is required, since a coarser sand usually gives a more open texture. The binder should be just sufficient to allow the core to hold up until the metal has set, without giving a hard resistant core. Molasses and water, or preferably some other water binder such as "Binderit," "Foundrite," or "Glutrin," will give good results if used in the correct proportions, while ordinary glue has also been used. If the core can be roughly handled it may be taken to be too hard for aluminium work. The cores should not be blacked, as the relatively low heat of the metal does not burn the sand, and the effect of blacking is to close the pores of the sand and reduce its porosity.

Magnesium in Aluminium.—According to Dr. W. H. Grosvenor ("Brass World"), the use of slightly less than 2 per cent. of magnesium in aluminium castings cleans up the aluminium and leaves 0.75 to 1.5 per cent. in the castings, almost doubling its strength and quadrupling its resistance to shock. It reduces the cost of machining more than 50 per cent., halving the number of resets on the cutting tool, giving clean-cut machine surfaces, and permitting a polish to be secured with the last cut instead of a separate operation. With

care, 1.5 per cent. of magnesium is found sufficient. The increase in strength means, in some cases, a reduction in weight of casting of 50 per cent. The reduction in casting weight is generally not less than 25 per cent. The weight of a pure aluminium casting may therefore be reduced, if 1.5 per cent. of magnesium is used, by from 25 to 50 per cent. This is a great saving even at normal prices of aluminium. The saving in machine work alone, when the casting is to receive much machining, it is contended more than pays for the use of magnesium.

Fine Surfaces on Brass Castings.—While most classes of brass castings are required to have merely a fairly good surface, others have to be supplied with the best possible finish. The essentials in producing this fine work are good workmanship and the correct moulding sand. French moulding sand is very popular and satisfactory, but there are other sands also which can be obtained from most good sand merchants who have specialised in foundry requirements. The pattern should be a good one, particularly smooth and free from "back" drafts or imperfect drafts. Ordinary iron flasks may be used, but snap flasks are unsuitable for such work. The pattern is faced with the fine moulding sand and backed up in the usual manner with ordinary bench sand. Otherwise the mould is made in the usual way. Lycopodium is generally used for the parting, and the mould is skin-dried by placing its face against a stove, but should not be dried right through. The surface of the casting is improved by smoking the face of the mould, after skin-drying, with a petrol or kerosene torch, which deposits a light coating of carbon to prevent the metal from adhering to the sand. The casting is poured either on end or flat as found necessary. The metal should, of course, be first-class if good results are to be obtained.

Manganese-Bronze Valves.—Comment has been made in the past on the unsuitability of manganese bronze, or similar alloys containing aluminium, for such castings as valves, owing to leakage under hydraulic pressure, although the castings may appear quite sound. The criticism of these alloys will be generally conceded to be correct, but it is interesting, however, to recall the claims put forward by W. Rübel, who conducted considerable work on aluminium alloys. He stated that the use of nickel, in combination with the manganese, iron and aluminium in the manganese-bronze, increases the density to such an extent that the valves stand a high pressure; and that the use of the nickel also increases the elastic limit. A special method of making the manganese-bronze mixture constitutes an essential for success. A preliminary alloy is made of the following:—Copper, 126 parts or 25.46 per cent.; iron, 112 parts or 22.63 per cent.; nickel, 175 parts or 35.35 per cent.; manganese, 55 parts or 11.11 per cent.; aluminium, 27 parts or 5.45 per cent. The metals are melted together and poured into ingots, and then to make the manganese-bronze the following mixture is taken:—Copper, 50 per cent.; zinc, 40 per cent.; preliminary alloy, 10 per cent. The final mixture works out as follows:—Copper, 52.55 per cent.; zinc, 40.00 per cent.; nickel, 3.53 per cent.; iron, 2.26 per cent.; manganese, 1.11 per cent.; aluminium, 0.55 per cent. A test-bar of this mixture was said to show a tensile strength of 85,000 lbs. per sq. in.

Melting Brass Chips.—Large quantities of brass chips are now being made, and many founders in attempting to re-melt them incur excessive loss. But the loss need be little more than about 5 per cent. if proper precautions are taken. The following summarises the instructions for such work given by one writer:—Use a large crucible; a small one is not satisfactory on account of the labour involved in charging and the mechanical loss of chips occasioned by their falling over the sides. Use a funnel-shaped charging device for putting the chips into the crucible. This can be made of sheet iron; it should project above the top of the furnace and have a handle at the side for lifting it out. When commencing, do not fill the crucible with chips; leave a certain amount of metal in the bottom of the crucible as a "button" after the previous pouring, and allow it to melt; then stir the chips into the bath of molten metal so that it will dissolve the chips at once and not allow them to reach a red heat or melt by themselves. The surface exposed to oxidation when the chips are melted alone is excessive and the consequent loss heavy. Keep plenty of charcoal on the crucible while melting, to prevent oxidation and waste of spelter. The latter does not volatilise as readily when the brass is kept covered with charcoal. Stir the metal frequently so that all the chips are dissolved and not left at the top of the crucible to oxidise and waste. Do not heat the metal too high, or it will cause rapid volatilisation of the spelter; but the metal in the bottom of the crucible must not be too cold or it will become chilled when the chips are added. Melt the button in the bottom of the crucible, and heat it so that the spelter begins to volatilise slightly; then at once stir the chips into it. Do not add too many chips at once or the mass becomes chilled; as soon as it begins to thicken, stop and allow it to heat again. Then add more chips, and continue the process until the crucible is filled. A handful of common salt thrown on the surface of the button before the melting begins will serve to clean the metal.

Case-hardening Bronze for Dies.—The bronzes which possess the greatness hardness lack the requisite properties for chasing and sinking fine intricate designs. It is, however, possible to obtain a hard face on a bronze by a process analogous to case hardening of steel, and this is practised with some bronze dies. The method is that of coating the surface of the die with pure tin, and then heating the die to a low red heat in order to alloy the tin with the surface of the bronze. As is well known, copper and tin unite in all proportions, and with from 20 to 30 per cent. of tin the alloy becomes quite hard. The surface of the die to be case-hardened is cleaned from grease by soaking in a strong hot potash solution and then immersing in a pickle or dip of acid to remove the oxide. A suitable pickle, which works more rapidly if hot, is made with 5 parts of water and 1 part oil of vitriol, and the die is allowed to soak in it for several hours until clean. It is then taken out and brushed, and the surface coated with a strong solution of chloride of zinc to act as a flux. The surface is then covered with pure, melted tin. The tin may be melted on the surface by a soldering-iron, but by far the best method is to use a torch or a blow-pipe. The tin is melted over the surface only, and as little as possible put on, as the fine detail of the die must not be filled up. The die is then washed in water to remove the excess of chloride of zinc flux and the surface examined. If there are any portions which are not covered with tin, the process is repeated. The next operation is to heat the die to a red heat, preferable in a muffle, though a blowpipe or torch may be used. To prevent the surface from oxidising, it is advisable to first cover it with a strong solution of boracic acid. Some boracic acid is dissolved in hot water and the solution lightly brushed over the surface. A light coat only is necessary. The die is placed on an iron plate to keep it from breaking when heated, as tin-bronze becomes brittle at a red heat, and it is heated to a low red heat and allowed to remain in this condition for ten or fifteen minutes. The plate is then removed from the muffle, and the die allowed to cool. The boracic acid is removed by soaking in hot water and afterwards pickling if necessary. After the foregoing operations, the surface of the bronze is quite hard, and difficult to cut with a file. Dies hardened by this method can be used for stamping leather, soft metals, paper and similar work, as they can be made originally soft enough for chasing or sinking with ease, and then hardened without destroying the design. The best results are obtained by using a rather soft bronze mixture with as little lead as possible. Such a bronze, high in copper, is not liable to give trouble by softening or cracking during the heating. A mixture recommended for this work is:—Copper, 88 lbs.; tin, 8 lbs.; zinc, 2 lbs.; and lead, 2 lbs.

War Material Order.

In pursuance of the powers conferred upon him by Regulation 30 (A) of the Defence of the Realm (Consolidation) Regulations, 1914, the Minister of Munitions has issued an Order (dated July 7, 1916) that the war material to which the Regulation applies shall include war material of the following classes and descriptions, namely:—

Metallurgical Coke of the following classes and descriptions:—Derbyshire, Durham and Northumberland, Lancashire, South Wales and Monmouthshire, Staffordshire, Yorkshire and Midland Counties.

Pig-iron of the following classes and descriptions: — Hematite, Cleveland, Derbyshire, Leicestershire and Nottinghamshire, Lincolnshire, Northamptonshire, Scottish, Staffordshire, Shropshire and Worcestershire.

High-Speed Tool Steel.

Notice of General Permit under the Order.

The Minister of Munitions gives notice that he hereby permits all persons until further notice:—(*a*) To buy, sell or deal in; or (*b*) offer or invite an offer or propose to buy, sell or deal in; or (*c*) enter into negotiations for the sale or purchase or or other dealing in the war material referred to in this Order, subject to the following conditions:—

(1) This permit shall not affect the provisions of Regulation 30 (B) of the Defence of the Realm (Consolidation) Regulations.

(2) No sale or purchase of material in the United Kingdom not being under a contract in writing entered into prior to the date of this notice shall be at a price exceeding the prices specified in the Schedule hereto with reference to the respective classes and descriptions of material therein referred to; PROVIDED THAT this condition shall not apply (1) to a sale or purchase under a special permit granted by the Minister of Munitions, or (2) to a sale or purchase which is not a transaction or one of a series of transactions involving the sale or purchase of more than five tons, or (3) to any sale by a manufacturer of finished steel rolled from steel purchased by him, or (4) to a sale or purchase of material the export of which has been duly sanctioned.

(3) Upon any such sale or purchase the seller and purchaser shall comply with any directions, whether of general application or otherwise, which may from time to time or at any time be given by the Minister of Munitions with regard to the use or disposal of the said war material.

Schedule.

The Schedule above referred to is as follows:

Maximum Prices for Metallurgical Coke.

	Per ton net. f.o.t., makers' ovens. £ s. d.
DURHAM and NORTHUMBERLAND—Blast-furnace coke	1 8 0
Do. Do. Foundry coke	1 10 6
LANCASHIRE .. .. Blast-furnace coke	1 5 8
MIDLAND COUNTIES .. .. .. Do. do.	1 5 8
SOUTH WALES AND MONMOUTHSHIRE Do. do.	1 10 0
SOUTH YORKSHIRE .. .. Do. do.	1 5 8
WEST YORKSHIRE .. .. Do. do.	1 5 8

Maximum Prices for Pig-iron.

	Per ton net. f.o.t., makers' works. £ s. d.
HEMATITE PIG-IRON—EAST COAST:—	
Mixed Numbers 1, 2 and 3	6 2 6
Special quality, containing under 0.04 of phosphorus and sulphur	6 7 6
Special quality, containing under 0.03 of phosphorus and sulphur	6 15 6
Special quality, containing under 0.02 of phosphorus and sulphur	7 0 0
HEMATITE PIG-IRON—SCOTTISH:—	
Mixed Numbers 1, 2 and 3	6 2 6
Special quality, containing under 0.03 of phosphorus and sulphur	6 15 6
Special quality, containing under 0.02 of phosphorus and sulphur	7 0 0
HEMATITE PIG-IRON—WELSH:—	
Mixed Numbers 1, 2 and 3	6 2 6
Special quality, containing under 0.03 of phosphorus and sulphur	6 15 6
Special quality, containing under 0.02 of phosphorus and sulphur	7 0 0
HEMATITE PIG-IRON—WEST COAST:—	
Mixed Numbers, 1, 2 and 3	6 7 6
Special quality, containing under 0.03 of phosphorus and sulphur	6 15 6
Special quality, containing under 0.02 of phosphorus and sulphur	7 0 0
CLEVELAND PIG-IRON:—	
Number 1	4 11 6
Other grades	4 7 6
DERBYSHIRE, LEICESTERSHIRE AND NOTTINGHAMSHIRE PIG-IRON:—	
Forge	4 5 0
Foundry Numbers	4 7 6
LINCOLNSHIRE PIG-IRON	
Basic or foundry	4 7 6
NORTHAMPTONSHIRE PIG-IRON:—	
Forge	4 2 6
Foundry Numbers	4 5 0
NORTH STAFFORDSHIRE PIG-IRON:—	
Forge	4 10 0
Foundry	4 12 6
Basic	4 15 0
SOUTH STAFFORDSHIRE, SHROPSHIRE AND WORCESTERSHIRE PIG-IRON:—	
"Part Mine" forge	4 10 0
"Part Mine" foundry	4 12 6
Common Staffordshire	4 5 0
"All Mine" forge	5 10 0
"All Mine" foundry	5 15 0
"Warm Air" forge	7 0 0
"Warm Air" foundry	7 10 0
Special Quality Lord Dudley's silicon	7 17 6
Cold-blast iron	8 17 6
SCOTTISH FOUNDRY AND FORGE PIG-IRON:—	
Nos. 3, 4 and lower grades of Monkland, Dalmellington, Eglinton, and Govan	5 14 0
Nos. 3, 4 and lower grades of all other brands	5 15 6
No. 1 quality (Scottish) to be 5s. per ton above these prices.	

To the above-mentioned prices for pig-iron a sum not exceeding 1½ per cent. on such prices may be added in the case of sales by persons other than the makers.

Maximum Basis Prices for Steel Scrap.

Heavy steel melting scrap, £5 10s. per ton delivered buyers' works.

Turnings and borings, £2 15s. per ton delivered buyers' works.

Maximum Prices for High-speed Tool Steel

Finished bars, 14 per cent. tungsten, 2s. 10d. per lb. delivered buyers' works.

Finished bars, 18 per cent. tungsten, 3s. 10d. per lb. delivered buyers' works.

(Subject to usual extras for special sizes.)

SCRAP.

Millings and turnings, 5d. per lb. net, delivered steel-makers' works.

Bar ends, 6d. per lb. net, delivered steel-makers' works.

All communications with reference to the above order and permit should be made to the Director of Materials, Armament Buildings, Whitehall Place, London, S.W.

LEAD-PLATED METAL PARTS.—The substitution of lead-plated steel for zinc and nickel-plated material and phosphor-bronze, copper and brass parts, used where metal must be protected from corrosion caused by acid, salts and fumes, has been made possible by the development of a process for lead plating that is being used by the United States Electro-Lead Plating Company, Cleveland, Ohio. The Willard Storage Battery Company has equipped a large plating plant in which the new process is used for plating grey and malleable-iron castings and steel stampings. From 15,000 to 20,000 parts are lead-plated every day, these being used for battery handles, screws, top connections, and terminals.

Certified Occupations.

A revised list of certified occupations, with age limits for single and married men, superseding previous lists, has been issued by the Local Government Board for the guidance of the Tribunals.

The regulations and instructions provide as to individual certificates that: (*a*) When exemption is claimed for a man on the ground that he is in a certified occupation he is entitled without further question to a certificate of exemption if the Tribunal are satisfied that his principal and usual occupation is a certified ocupation; except that (*b*) a military representative may, on due notice, require a Tribunal also to consider the question whether, notwithstanding that the man is in a certified occupation, it is necessary to retain him in civil employment. If this question is properly raised, and the Tribunal are satisfied that it is not necessary in the national interest to retain the man, they are not to grant exemption on the ground that he is engaged in a certified occupation.

The conditions as to age and marital condition, where applicable, are indicated in the list opposite the several occupations. When an age limit for exemption is stated, the age referred to is in all cases, except agriculture, the age at April 4, 1916; that is to say, men who had not reached the ages stated on April 4 are not covered, and do not become covered by reason of having subsequently attained the specified age. Men who on November 2, 1915, were unmarried or were widowers without any child dependent on them are to be treated as single men for the purposes of this list.

A provision is that though a man in any of the occupations scheduled is not of an age or marital condition that entitles him to be treated as in a certified occupation, he is nevertheless to be so treated if, before his case has been decided by the Tribunal, he has been found, on examination by a Recruiting Medical Board, not to be fit for General Service (Category A).

With the exception of those employed in the industries marked (*a*), men employed in the occupations named in the list are covered only if they can show that they were engaged in the same occupation on or before the date when the National Register was made, namely, August 15, 1915.

No man, whether attested or unattested, so long as he rightfully holds a certificate in connection with a War Service badge, at whatever date it was issued, and whether he still holds a badge or not, is liable to be called up for service with the Colours.

General Reservations.

	Age limits for Single Men.
Engineman or engine tenter	25*
Power crane driver	25
Stoker or boiler fireman	25
Electrician or electrical fitter engaged in the maintenance or repair of motors and other electrical plant in factories	30
Mechanics and similar men engaged in the maintenance or repair of their employers' plant, machinery or tools	25
Tool maker; tool fitter; tool setter; die sinker	—
Works chemist	25*
Carter, lorryman and drayman (horse or power) employed by carting contractors in connection with railways, docks, wharves or warehouses	—
Do. Employed by public carriers of goods by road	25
Do. Others, in all trades (except coal trade), not engaged in collecting from or delivering to private houses	25

Metal, Engineering and Shipbuilding Trades.

(*a*) Pig-iron Manufacture, Blast Furnaces:—All classes of workmen	—
(*a*) Steel Manufacture:—All classes of workmen	—
(*a*) Iron and Steel Rolling Mills, and Puddling Furnaces:—All classes of workmen	—
Tinplate and Steel Sheet Manufacture:—All classes of workmen	†
Tin Smelting:—All classes of workmen	—
Zinc Smelting:—All classes of workmen	—
(*a*) Ship and Barge Building and Repairing:—All classes of workmen	—
(*a*) Marine Engineering:—All classes of workmen	—
Weighing Machines, Scales and Balances:—Adjuster and repairer	30
Other Engineering Works and Iron Foundries, engaged in Manufacturing or Repairing Machinery or Plant for use in Industry:—All classes of workmen	36
(*a*) Anchor-making:—All classes of workmen	—
Blacksmith (including farrier)	25
(*a*) Chain Making:—Block chains:—All classes of workmen	—
Do. Other Chains:—All classes of workmen (except men engaged on chains of less than ⅛ in. diameter)	—
Electrical Accumulator Manufacture:—Departmental manager; foreman	30
Do. Caster; mixer; paster; lead burner; forming man; battery erector	25
Heavy Edge Tool, Pick, Spade, Shovel and Hoe Manufacture:—All classes of workmen except wood turners	41
Slag wool maker	30
Tin Box Manufacture:—Foreman	30
(*a*) Tube and Tube Fittings Manufacture: Iron, Steel, Copper and Alloys (for engineering and shipbuilding):—All classes of workmen	—
Wheelwright	30

* Where the man in charge of the principal power engines or the works chemist, at important works is under 25, and is the only man left in that position, he should be exempted.

† All classes of workmen are reserved up to the end of August without distinction of age or marital condition; but, on and after the 1st September, 1916, single men under 35 years of age will not be reserved if they are passed by a Recruiting Medical Board as fit for general service

British Steel Statistics for 1915.

Electric Steel and Steel Castings.—Supplementing the 8,350,944 tons of Bessemer and open-hearth steel ingots returned for 1915 a total of 20,000 tons of electric steel ingots, 177,071 tons of steel castings and 2,000 tons of electric steel castings brings the total steel output for the year (excluding crucible steel) up to 8,550,015 tons, compared with 7,835,113 tons returned for 1914 and 7,663,876 tons for 1913.

Production of Ferro-Alloys in the Electric Furnace in 1915

	Tons.
Ferro-silicon	1,500
Ferro-tungsten	1,250
Ferro-chrome	2,000
Other ferro-alloys	500
Total ferro-alloys	5,250

Steel Furnaces in 1915.

	Acid.	Basic.	Total.
Average number of converters active	47	14½	61½
Average number idle	24	11½	35½
Total converters	71	26	97
Average number of O.-H. furnaces active	336½	152½	489
Average number idle	77½	25½	103
Total open-hearth furnaces	414	178	592

Electric Furnaces in 1915.

	At work.	In construction
Héroult	15	10
Electro-Metal	4	6
Stassano	2	0
Snyder	0	4
Rennerfelt	1	2
Stobie	1	0
Total electric furnaces	23	22

Trade Talk.

THE MACHINE TOOL ATTACHMENT COMPANY, of Longsight, Manchester, are erecting new works at Reddish.

EDGAR ALLEN & COMPANY, LIMITED, have removed their London offices to 1, Victoria Street, Westminster.

CAST IRON BRAZIERS AND METALLURGISTS, LIMITED, is being wound up voluntarily, with Mr. F. Say, 90, Banner Street, E.C., as liquidator.

THE business of the Govan Shafting Company, 6, Summertown Road, Govan, has been acquired from A. Anderson and M. P. Morrison, by the Govan Shafting and Engineering Company, Limited.

AT a meeting of the Swansea Harbour Trustees on July 12, it was decided that the consolidated rate on scrap iron be increased from 3s. 1½d. to 3s. 6d. a ton from August 1.

MR. A. F. BUNDEY, manager of the Metal & Hardware Products, Limited, has established himself in business as an engineer at Fulwood House, High Holborn, London, W.C.

THE SHERARDIZING SYNDICATE, LIMITED, is being wound up voluntarily, with Mr. R. J. R. Warner, 34, Ebury Street, London, S.W., and Mr. C. J. Jones, 24, Wood Vale, Forest Hill, London, S.E., as liquidators.

MESSRS. R. L. SERVICE and F. H. BRADY (trading as Robert L. Service and Partners), Railway Foundry and Engineering Works, Vastern Road, Reading, and 119-120, London Wall, London, E.C., have been adjudicated bankrupts.

THE London office of the British Engine, Boiler and Electrical Company, Limited, has been removed to Imperial Buildings, 56, Kingsway, W.C. Mr. H. F. Taylor, secretary of the company, has been appointed London manager.

THE partnership heretofore subsisting between Messrs. P. Schofield and E. Holmes, carrying on business as marine and general engineers, etc., at 347, Chester Road, Manchester, under the style of Edward Holmes & Company has been dissolved.

IN a paragraph in our June issue, relating to the Snyder electric furnace, reference was made to Mr. Lake, of Messrs. Lake & Elliott, Ltd., Braintree, as being managing director of the Snyder Electric Furnace Company. We are requested to state, however, that this is incorrect.

THE Controller of the Foreign Trade Department has issued a number of additions to the statutory list of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. In respect to Morocco the list now issued supersedes all previous lists for that country.

THE blast furnaces, steel works, and other properties of the Glengarnock Iron & Steel Company, Limited, also the works of the Glengarnock Chemical Company, Limited, have been acquired by David Colville & Sons, Limited, Dalzell Steel & Iron Works, Motherwell. Messrs. Colville took over possession on July 1.

THE MINISTER OF MUNITIONS announces that he has made further orders under the Munitions of War Acts, 1915 and 1916, under which 339 additional establishments have been declared controlled establishments. The total number of controlled establishments under the Munitions of War Acts, 1915 and 1916, is now 3,916.

THE PRESIDENT OF THE MANCHESTER ASSOCIATION OF ENGINEERS (Mr. F. W. Reed, of Craven Bros. (Manchester), Limited) and Mrs. Reed entertained the members and their friends at a garden party at the Grange, Reddish, on July 22 last, the guests numbering 250. There was an interesting programme of music and recitals.

THE VENTURE TRUST, LIMITED, has formed the British Electrolytic Zinc Company (Isherwood Process), Limited. The capital of the new company is £62,500 in shares and £25,000 in debentures authorised, of which there has been issued £42,400 in shares and £21,200 in debentures. The company has acquired the Isherwood process for the electrolytic treatment of zinc in Great Britain.

HENRY R. MERTON & COMPANY, LIMITED, have issued a notice in which they state that the shares in the company which were hitherto held by German firms have now all been acquired by British subjects. The company has altered its articles of association, which now contain very stringent provisions, by virtue of which the company is now and will always remain under exclusively British control.

THE STAVELEY COAL AND IRON COMPANY, LIMITED, have secured an order, in face of keen American competition, for the supply of 26,000 tons of cast-iron pipes to the Argentine Public Health Works Department, the total value of the contract being practically £262,500. The price quoted by the American concerns was lower than that of the Staveley Company, but the former could not guarantee delivery within the specified time, viz., by the close of the present year.

A SCHEME is at present on foot for a very considerable extension of the Foyle shipyard, owned by the North of Ireland Shipbuilding Company, Limited, at Pennyburn. When the yard was started, only a few years ago, four acres were taken from the Londonderry Port and Harbour Commissioners. The industry has been making rapid progress since then, and, under the new arrangement which the directors are making with the Commissioners, the yard will comprise a total of 24 acres.

ORDERS have been made by the Board of Trade requiring the undermentioned businesses to be wound up:—Poldi Steel Works, Napier Street, Sheffield, steel manufacturers. Controller: A. Duncan Barber, Sheffield Telegraph Buildings, High Street, Sheffield. A. Barson & Company, 57, Scrutton Street, E.C., engineers' tool manufacturers. Controller: Adam Turquand Young, 41, Coleman Street, E.C. Kuxmann & Company, Victoria Foundry, Huntingdon, agricultural implement manufacturers. Controller: Howard William Cox, 5, Petty Cury, Cambridge.

ON the motion of the plaintiff in a debenture holder's action, Newall *v.* Electro Flex Steel Company, Limited, Mr. Justice Astbury, in the Chancery Division, has appointed a receiver and manager of the defendant company. Counsel said the company had passed a resolution to voluntarily wind up, but it was important that the business should be continued. The shareholders of the Electro-Flex Steel Company, Limited, having decided to wind up the company voluntarily, have appointed Mr. B. A. FitzGerald, Collingwood Buildings, Newcastle-upon-Tyne, as liquidator.

THE SKEFKO BALL BEARING COMPANY, LIMITED, are making very extensive improvements and alterations to their works and buildings in the Leagrave Road, Luton, Beds. We understand these extensions are already in hand and should be in full swing within the next few months. The company commenced manufacturing in 1911, and the increased demand for their product has necessitated almost continuous extensions to the works. A new district office for Scotland has been opened at 45, Bothwell Street, Glasgow. The district manager, Mr. J. D. Allan, has been representing the company, technically, for several years past.

A MEETING of engineering and shipbuilding draughtsmen was held in Newcastle on July 24, for the purpose of forming a Tyneside and District Branch of the Association of Engineering and Shipbuilding Draughtsmen. Mr. Blair, secretary of the General Council, said that up to the present over 500 members had been enrolled for Tyneside alone, and that it was expected before the end of August at least 200 more would have joined. Members of the Executive Council also spoke, after which a motion was passed that it was advisable to form a branch on Tyneside, to be affiliated with the association.

MESSRS. LAWSON, WALTON & COMPANY, Mosley Street, Newcastle-upon-Tyne, advise us that they have taken over the operating of the Boldon Foundry-sand Quarry. They claim considerable merits for the

material as a moulding, core and furnace sand, and state that it is used by a large number of foundries and iron and steel works on the North-East Coast. This Boldon foundry sand is stated to consist of a hill or cliff of "Rotten Rock," or decomposed sandstone—geologically "dolomite." An analysis showed the following:—Silica, 88.36 per cent.; alumina, 4.35 per cent.; oxide of iron, 0.71 per cent.; lime, 1.60 per cent.; magnesia, 0.74 per cent.; alkalies (calculated as soda), 1.70 per cent.; loss on ignition, 2.59 per cent.; manganese, trace.

Mr. Lloyd George has forwarded a communication to Mr. Redmond reviewing the work of the Ministry of Munitions in Ireland since the establishment of the Ministry in Dublin in the middle of August, 1915. Contracts have been placed in 14 cities and towns in the south and west alone, with about 45 private firms, apart from railway companies, for one and a half million shells, fuses, and components, and considerably over one million ammunition boxes. The total expenditure involved up to date, including national factory buildings and machinery, exceeds £800,000. Mr. Lloyd George adds that the total value of the direct War Office contracts placed in Ireland from the outbreak of war to May, 1916, including the value of materials supplied, amounts to £4,350,666.

The Secretary of the Ministry of Munitions forwards the following for publication:—In pursuance of the powers conferred on him by Regulation 30A of the Defence of the Realm (Consolidation) Regulations, 1914, the Minister of Munitions hereby orders that the war material to which the regulation applies shall include war material of the following classes and descriptions, namely:—Aluminium and alloys of aluminium, unwrought and partly wrought, including ingots, notched bars, slabs, billets, bars, rods, tubes, wire, strand, cable plates, sheets, circles, strip. Granulated aluminium, aluminium powder, "bronze," "flake," and "flitter." The Order, dated December 7, 1915, published in the "London Gazette" of the same date, relating to all kinds of aluminium and alumina, is hereby cancelled. All applications for a permit in connection with the above Order should be addressed to the Director of Materials, Ministry of Munitions, Armament Buildings, Whitehall Place, S.W.

It is announced that the scheme, previously reported, for building standardised ships at Chepstow, on the Wye, will be launched with a capital of £300,000, which has been privately subscribed. The shareholders include the following shipping companies:—P. and O. and British India (of which Lord Inchcape is chairman), New Zealand Shipping, Orient Steam Navigation (F. Green & Company and Anderson, Anderson & Company, managers), Federal Steam Navigation, Furness, Withy & Company, Shire Line (Turnbull, Martin & Company), A. Weir & Company, Harris & Dixon, Limited, Trinder, Anderson & Company, Bethell, Gwynn & Company, and Birt, Potter & Hughes, Limited. The chairman of the company is Mr. J. Caird, and the vice-chairman Mr. J. H. Silley, managing director of R. & H. Green & Silley Weir, Limited. The other directors are Mr. F. E. Dixon, Mr. J. Esplen, Mr. J. B. Gray, Mr. R. H. Green, Mr. A. Hughes, Mr. F. W. Lewis, and Mr. A. Weir. The secretary is Mr. J. Patterson, 112, Fenchurch Street, E.C.

Complaint is being made by many manufacturers, particularly in the Midlands, at what they allege to be unfair treatment by the Ministry of Munitions in regard to the demands made by the Department for the surrender of machinery. The complaint of the manufacturers is that when a call for plant is made by the Ministry, effect is given to it in such a way as unnecessarily to impose the maximum amount of inconvenience and loss upon a few firms, and to allow their competitors to escape altogether. During the past few weeks, for instance, a few firms have been called upon to give up their machinery to the Ministry; but many other firms in at least an equal position to those affected have been ignored. In such cases, the manufacturers say, the Ministry ought to make a pro-rata levy all over the district, instead of singling out half a dozen or so firms. The Birmingham Chamber of Commerce, it is understood, have been asked by the manufacturers to investigate the matter, and lay the facts before the Government.

Mr. Houston asked the President of the Board of Trade on July 20 the nominal amount of the share capital of Thermit, Limited; how much of that share capital had been issued; how much was held by British-born subjects resident in the United Kingdom, and how much by aliens resident in Germany; the names of the directors and manager of the company; whether the company enjoyed the protection of British patents which prevented other British companies or firms from carrying out similar operations. Mr. Harcourt, in reply, said: "The nominal capital of Thermit, Limited, is £50,000, the whole of which has been issued and was held by or on behalf of Germans resident in Germany. The directors of the company before the war were Karl Goldschmidt, Hans Goldschmidt, and E. Stassfurth, resident in Germany, and R. Stutz, a naturalised British subject resident in this country. Since the war the business has been managed by Mr. Stutz subject to the supervision of a controller appointed by the Court on the application of the Board of Trade. The company owns certain patents in respect of all of which licences can be granted by the Board of Trade to British firms and licences have been granted to one British firm. The shares of the company were vested in the public trustee under the provisions of the Trading with the Enemy Amendment Act, 1916, and he has recently entered into an agreement to sell the whole of those shares to a British company." Thermit, Limited, inform us that they have received an official notification from the Public Trustee to the effect that he has entered into an agreement to sell the whole of the enemy shareholding in the company to the Birmingham Metal and Munitions Company, Limited, Birmingham. The company will continue to trade in exactly the same way as hitherto.

The Millom & Askam Hematite Iron Company, Limited, have purchased from the Duke of Devonshire the whole of his share interests in the Barrow Hematite Steel Company, Limited. The negotiations, which have been in progress for some time, were brought to a conclusion about the beginning of June, and thus has ceased the long association of the heads of the Cavendish family with iron manufacture at Barrow-in-Furness. The Duke resigned (as is usual in such cases) his directorship of the Barrow Company on his appointment as a Civil Lord of the Admiralty on the formation of the Coalition Ministry. The Cavendishes have probably been more intimately connected with the iron and steel industry than any other of the great families of this country. The seventh Duke was the first President of the Iron and Steel Institute, and the present Duke occupied the position in 1910-12. Lord Frederick Cavendish, up to the time of his assassination in Phœnix Park, Dublin, took an active interest in the iron trade. They will still remain connected with the industry as large royalty owners, but it is with Barrow that their name has been particularly identified. The Barrow company was registered in 1864. The properties include the Barrow colliery, near Barnsley, Yorkshire, also the Park and Yarlside iron ore mines in the Furness district. In 1907 the company secured interests in iron ore mines in Algeria, now represented by shares in the Beni-Felkai Mining Company, Limited. The Company have ten blast furnaces, of which six or seven are now in blast, and the steel works include Bessemer and open-hearth steel plants, and plate, rail, bar and hoop mills. The Barrow capital was originally £150,000 in £100 shares, but is now £916,965. The Millom and Askam company was registered in 1890 to acquire the works of the Cumberland Iron Mining & Smelting Company, Limited, at Millom, Cumberland, and of the Askam & Mouzell Iron Company, Limited, at Askam. The company now owns or leases:—Millom Ironworks on the Cumberland side and Askam Ironworks on the Lancashire or Furness side of the Duddon Estuary, both near Barrow-in-Furness, with shipping wharves beside each ironworks, lands, workmen's and other houses, railways, etc.; Redhills Lime-

stone Quarry near Millom Ironworks, and Goldmire Limestone Quarry near Askam Ironworks. They also have mineral rights in various areas in Cumberland. The company has also investments in other companies. The capital is £300,000.

In presiding at the luncheon given to the members of the Empire Parliamentary Association on the occasion of their visit to the East Hecla Works, Sheffield, of Hadfields, Limited, on Tuesday, July 11, Sir Robert Hadfield remarked that he was particularly delighted that the company included the chairman of the Advisory Council for Scientific and Industrial Research, Sir W. M'Cormick, who was directing a great work in London to help the Empire, namely, the encouragement of research by the State in this country. Assistance should be given them by monetary grants which would be of use not only to Sheffield but to the Empire, in encouraging them to help on the important work of applying science to industrial needs. Any deficiencies in the past with regard to slower scientific development had been largely due to the want of appreciation by the State in fostering and aiding science. The policy had really been niggardly, and science had been far too much neglected. As regards the position of Great Britain, it had never been clearly proved, at any rate with regard to metallurgy, that the country had been behind; in fact it led the way. It seemed to him, however, that there were three specially important points which they all ought to bear in mind: First.—There had been far too little encouragement of scientific research by the State. Second.—The import of bounty-fed products should be stopped. Their German competitors for years were obtaining bounties of from 15s. to 20s. per ton on iron and steel exported by them. Whilst for the time being buyers in this country might have benefited by the cheaper price, what was the result? New works for the manufacture of iron and steel could not be put down. Now in time of war they found it was necessary to buy steel from America, a pretty state of things when they had had all the knowledge and talent for installing factories in their own country. In fair competition with Germany or any other country they were quite prepared to hold their own. The contest between the two countries had been mainly one of cost of land or sea carriage. Third.—Lower railway freights should be made possible, and without doubt the true remedy in that respect was that the railways should be State owned. When speaking of State aid he could not help referring to the further developments of the Krupp works at Munich. Those were without doubt being undertaken by State aid, which he trusted would make the Government Departments in this country take a generous point of view in helping various developments of steel production and machine shops in order to meet the serious competition such as the above further increase of Krupp's works presages. If they were properly assisted on the three points above mentioned, he was more than confident that they could not only hold their own, but show still greater progress. With proper State encouragement for science, and applying that science to industry, there was nothing their enemies could do that he felt sure those in Great Britain could not accomplish still better.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Coles, S. O. Cowper-. Process for refining zinc. 9,212. June 30.

Davis, H. N. Furnaces. 9,543, 9,544, 9,545. July 6.

Elborne, W. Manufacture and use of aluminium compounds. 9,604. July 7.

Hunton, H. C., & Mitchell, J. Lead, &c., casting-machine. 9,389. July 4.

Jones, J. H. Steel-ingot compression mill. 9,077. June 28.

Miles, F. W. Furnaces for melting metals. 9,085. June 28.

Pickering, T. Alloy. 9,387. July 4.

Steinberg, S. Electric furnace for steel melting. 9,055. June 27.

Sulver, C. Furnaces. 9,339. 9,340. June 30.

Personal.

Mr. George Bean has relinquished his position as managing director of Allen Everitt & Sons, Limited.

The late Captain G. H. Coates, co-managing director of the Whessoe Foundry Company, Limited, left estate valued at £5,508.

Mr. E. M. Wrong, Fellow of Magdalen College, Oxford, has been appointed Vice-Principal of the Manchester School of Technology.

The gross value of the estate of the late Mr. Stanley Dorling, of Henrietta Street, Cavendish Square, W., engineer and contractor, is £12,575.

Mr. R. Clough, a director of the Keighley Gas & Oil Engine Company, Limited, has been added to the Commission of the Peace for Keighley.

Mr. Thomas Britten, manager of the works at Chelmsford, of Crompton & Company, Limited, has been elected by the directors to a seat on the board.

Vice-Admiral Sir Richard H. Peirse, K.C.B., M.V.O., has been appointed Naval Member of the Central Committee of the Board of Invention and Research.

The late Mr. E. Crompton, a founder of the firm of Cochran & Co., engineers, Annan, has left property of the gross value of £6,053 9s. 5d., with net personalty £5,996 5s. 6d.

Sir John Randles, M.P., was on Thursday presented with the freedom of Workington in recognition of his services in developing the industries of that borough and of West Cumberland.

Dr. O. F. Hudson, lecturer in metallography and assaying instructor at the Birmingham University, has been appointed assistant investigator to the Corrosion Committee of the Institute of Metals.

Captain Wm. T. Mitchell (reported wounded and missing), is a son of the late Mr. W. T. Mitchell, of the Grahamston Iron Company, Falkirk. He is a ship owner in Glasgow and a director of the Grahamston Iron Company, Limited.

Mr. G. Rigg, one of the world's foremost zinc experts and for a number of years chief metallurgist of the New Jersey Zinc Company, has been appointed consulting metallurgist to the Broken Hill Associated Smelters Proprietary, Limited, Australia.

Mr. W. Eccles has been appointed by the executive committee of the City and Guilds of London Institute to the professorship of Electrical Engineering and Applied Physics at the Institute's Technical College, Finsbury, rendered vacant by the death of Professor Silvanus Thompson.

Mr. A. F. Ericsson has been elected chairman of the Weardale Lead Company, Limited, in succession to Mr. G. Richardson, who has resigned through ill-health. Mr. E. P. Deas has been elected a director of the company to fill the vacancy caused by the death of the late Mr. J. I. Clark.

Mr. J. Pugsley, Mr. G. Pugsley, Mr. E. T. Pugsley and Mr. F. C. Pugsley are the first directors of Joseph Pugsley & Sons, Limited, Cattybrook Iron Works, Bristol. Mr. G. Pugsley will be the managing director of the company, while Mr. E. T. Pugsley will manage the London depôt.

Captain M. Charles Wade has been slightly wounded, but was able to remain on duty. Captain Wade is the eldest son of Mr. H. L. Wade, of the firm of Charles Wade & Company, Limited, Midland Ironworks, Aston Road, Birmingham, of which firm Captain Wade is also a director.

Mr. G. Hatton, of Hagley, has received official information that his second son, Captain G. A. Lyon Hatton, of the Queen's Own Royal West Kent Regiment, is reported missing. Captain Hatton, whose father is the managing director of the Earl of Dudley's Round Oak Works, Limited, joined the colours in September, 1914, and has been on active service for more than a year.

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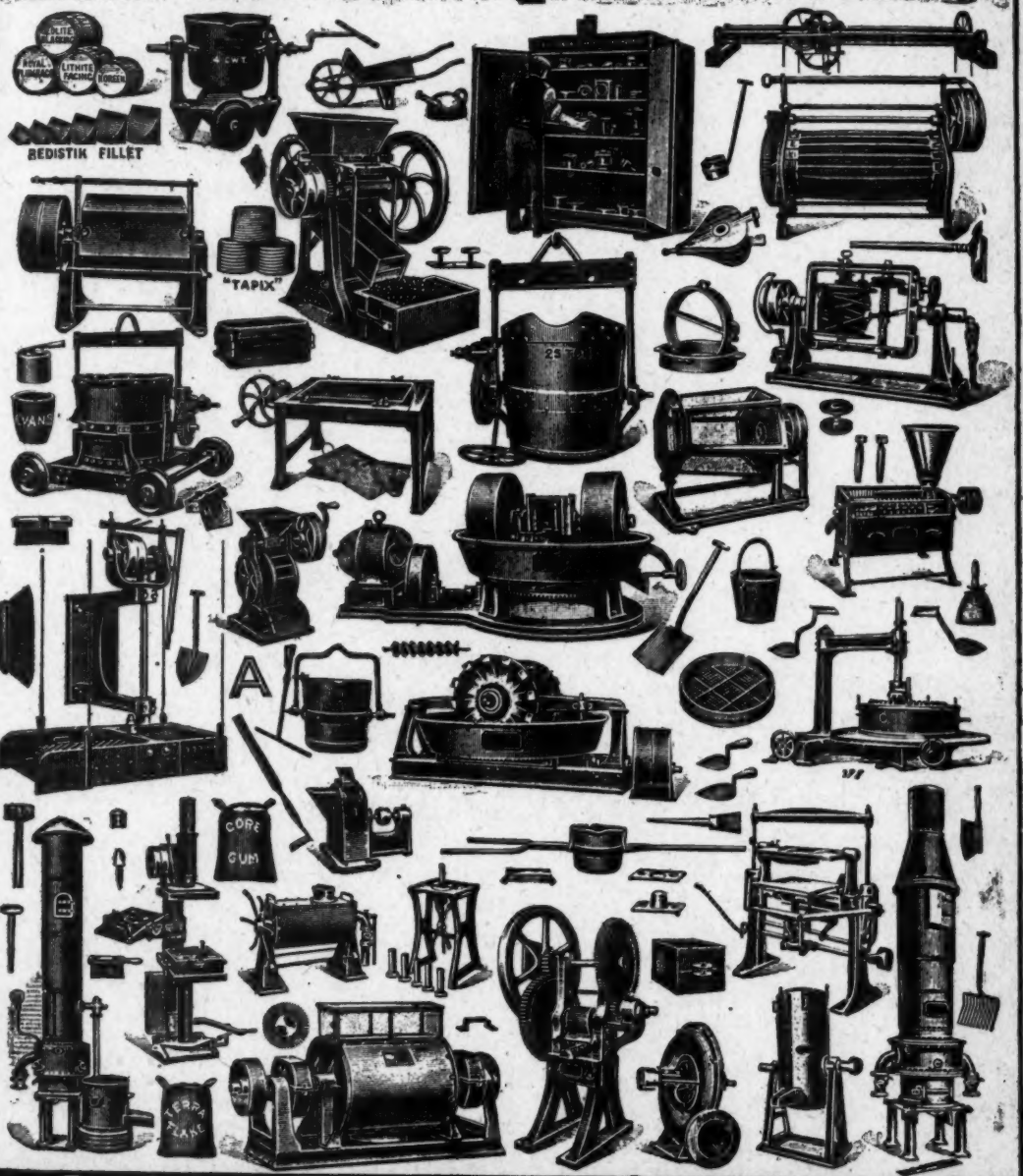


JAMES EVANS & Co. BRITANNIA WORKS, BLACKFRIARS, MANCHESTER.

Deaths.

THE death is announced of Mr. Charles Henry Thompson, head of Chalk Hill Ironworks, Norwich.

THE death is recorded of Mr. R. Morley, principal of the firm of Morley Bros., coppersmiths and sheet-metal workers, Folly Hall, Huddersfield.

MR. N. ROBSON, of the firm of William Dixon, Limited, iron and coal masters, Glasgow, died on July 25, at this residence at Kilbarchan.

THE death took place recently of Mr. G. W. Corbett, until recently senior partner in Messrs. Corbett and Son, Park Street Engineering Works, Wellington, Salop.

MR. G. ANDREWS, works manager at the Lynton Engineering Works, Bedford, has died in hospital as the result of injuries received in a motor-car accident near Bedford on July 15.

MR. T. H. MILLS, White Bank House, Brinnington, Stockport, managing director of the Bredbury Steel Works, has died at Harrogate. He was the son of Mr. J. Mills, who founded the business.

THE death took place recently of Mr. James Ritchie, managing director of James & Ronald Ritchie, Limited, Acklam Foundry, Middlesbrough. The deceased gentleman has controlled the operations of the firm since its inception in 1882.

THE death is announced in the German technical press, at the age of 75, of Herr Franz Haniel, who was for many years connected with the engineering firm of Messrs. Haniel & Lueg, of Düsseldorf, and also with the Gutehoffnungshütte.

MR. W. F. RUSSELL, a partner in the firm of S. Russell & Sons, brass and iron founders and engineers, Bath Foundry, Bath Lane, Leicester, died recently. The business will be continued as a partnership between Mr. Samuel Russell, the remaining partner, and his two sons, Mr. S. Hibbert Russell and Mr. W. Sidney Russell.

NEWS has been received in Sheffield of the death in action of Captain W. A. Colley, of the York and Lancasters. The deceased was a director and secretary of W. A. Colley, Limited, crucible steel makers, of Millsands, Sheffield, and a former member of the Sheffield City Council. He was 47 years of age, and served in the Sheffield Territorial Engineers before joining one of the new battalions.

THE death occurred, on July 21, at his residence, High Warden House, Whitley, of Mr. Alexander Baird. Born in Newcastle 74 years ago, he entered the works of Messrs. Hawthorn at Forth Banks at the age of eight, subsequently rising to the position of works manager—a position which he relinquished some years ago, but was retained as consulting engineer, thus having a service of 66 years with the firm.

INFORMATION has been received lately that Mr. Herbert Barber, of Oakhurst, Sheffield, has lost a son, Captain Herbert Graham Barber, of the York and Lancaster Regiment, in the war. The deceased officer was 31 years of age, and was educated at Leighton Park School, Reading. He entered the firm of Daniel Doncaster & Sons, Limited, in 1903, and became a director in 1909. He was awarded the Military Cross recently.

CAPTAIN JAMES SAMUEL DAVIDSON, Royal Irish Rifles, who has been killed in action, was the only surviving son of Mr. S. C. Davidson, of Seacourt, Bangor, County Down, founder and managing director of the Sirocco Engineering Works, Belfast, of which firm Captain Davidson was himself a director, and for many years, prior to the outbreak of war, acted as general manager. He was 38 years of age, and was a member of the Institute of Mechanical Engineers, and a governor of the Royal Academical Institution, Belfast, at which school he was educated.

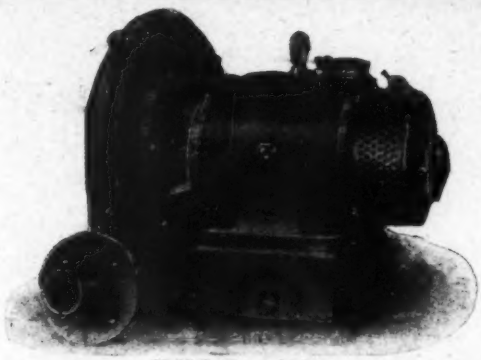
THE death occurred in action on July 1 last of Captain William Morton Johnson, M.A., Manchester Regiment. Captain Johnson was the eldest son of the late Mr. W. H. Johnson, B.Sc., both having been members of the Manchester firm of Richard Johnson, Clapham & Morris, Limited. Captain Johnson was particularly associated with the splendidly arranged works which his company erected at Newton Heath. He was an original member of the Institute of Metals, of which his father was one of the founders.

DEEP regret was expressed in iron and steel circles when it became known that Mr. T. E. Dodgson, a director and general manager of the Parkgate Iron and Steel Company, Limited, had died at his residence, Granby House, Parkgate, on July 24. The deceased gentleman commenced his employment with the firm about 48 years ago, and gained gradual promotion, and after a period as assistant manager was made manager in 1900, and general manager in 1911. Mr. Dodgson became a director of the company this year.

THE death has taken place at Arnside, of Mr. T. W. Worsdell. The deceased gentleman was born at Liverpool in 1838, his father being the superintendent of the coach-building department of the Liverpool and Manchester Railway. Mr. T. W. Worsdell entered the drawing office of the locomotive department of the London and North-Western Railway at Crewe, about 1858. He was appointed Master Mechanic of the Pennsylvania Railway in 1865, but returned to Crewe in 1871 as manager of the L. and N.W. locomotive department. In 1881 he became locomotive superintendent and mechanical engineer of the Great Eastern Railway, but four years later accepted the post of locomotive, carriage, and wagon superintendent of the North-Eastern Railway.

MR. T. R. OSWALD, whose death has occurred at Blackheath, was a member of the Institution of Naval Architects, and a well-known shipbuilder. Born in 1836, a son of the late Mr. William Oswald, of Highbury, London, and brother of the late Mr. James Oswald, K.C., some time M.P. for Oldham, he commenced his shipbuilding career in 1852 with his uncle, Mr. James Laing, afterwards Sir James Laing, at Deptford Yard, Sunderland. Two years later he entered the shipbuilding and engineering yard of Messrs. J. Scott Russell & Company, of Millwall, where he took part in building the "Great Eastern." In 1857 he built his first ship at Sunderland, and from that time constructed there a large number of vessels, till he moved to Southampton in 1875, and laid out a large yard at Woolston. Having moved to Milford Haven in 1889, he continued to carry on for some time important work in the building and repairing of vessels.

WE regret to announce the death of Sir Wm. Ramsay, which occurred at Hazlemere, High Wycombe, on July 23, at the age of 63 years. The deceased gentleman was responsible for some of the most important scientific discoveries of modern times, more particularly in the realms of chemical science. His name is indissolubly associated with such discoveries as the presence of argon and other allied gases in the atmosphere, the identity of helium on earth with an element previously only known to exist in the sun's atmosphere, and the cardinal fact of the transmutation of radium into helium. His first laboratory was his home at Glasgow, where he carried out his earliest recorded experiment, the preparation of oxalic acid from sugar. In his 14th year he matriculated at Glasgow University, where he came under the influence of William Thomson, afterwards Lord Kelvin. A term under Bunsen at Heidelberg followed, and then he went to Tübingen, working for two and a half years in Fittig's laboratory. Returning to England at the age of 21, he acted for two years as tutorial assistant in chemistry at the Young Laboratory, followed by six years in a similar position at Glasgow University. In 1880 the Professorship of Chemistry at University College, Bristol, was entrusted to him. A year later, Professor Marshall, the principal of the College, resigned, and Sir William was appointed to succeed him. He remained at Bristol till 1887, when Professor Alexander Williamson retired from the Chair of Chemistry at University College, London, and Sir William was elected to fill it. In 1913 Sir William Ramsay retired from the Chair of Chemistry at University College.



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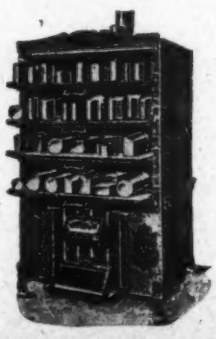

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New Companies.

Wey Engineering Company, Limited.—Capital £6,000 in £1 shares. Registered office: Baker Street, Weybridge.

Alberta Engineering Company, Limited. — Capital £10,000 in £1 shares. Registered office: 4, Copthall Chambers, E.C.

Robin Hood Engineering Works, Limited.—Capital £10,000 in £1 shares. Registered office: Newlands, Putney Vale, Surrey.

Millward & Hughes, Limited.—Capital £12,000 in £1 and 1s. shares, to purchase the business of Millward & Hughes, brass founders, etc., Birmingham.

Biggar & Hendry, Limited.—Capital £3,500 in £1 shares, to acquire and carry on the business of engineers' factors. Registered office: 159, Howard Street, Glasgow.

Light & Company (Chippenham), Limited.—Capital £1,000 in £1 shares, to acquire the business of W. Light & Company, Limited, engineers, etc. Registered office: Union Road, Chippenham.

Elliott Brothers (London), Limited.—Capital £90,000 in £1 shares, to acquire the business carried on by W. O. Smith and others at Century Works, Lewisham, and elsewhere, as Elliott Brothers, mechanical and electrical engineers, etc.

Joseph Pubsley & Sons, Limited.—Capital £20,000 in £1 shares, to take over the business of machinery and metal merchant at the Cattybrook Iron Works, Lawrence Hill, Bristol, and at 72-74, Queen's Circus, Battersea Park, S.W.

T. M. Birkett & Sons, Limited.—Capital £10,000 in £1 shares, to take over the business of a brassfounder, etc., carried on by T. M. Birkett at Marsh Street, Hanley, as T. M. Birkett & Sons. Registered office: Thomas Street, Hanley.

J. Legge & Company, Limited.—Capital £30,000 in £1 shares to carry on the business of lock manufacturers as formerly carried on by J. Legge and H. H. Chilton at the Colonial Works, Stafford Street, Willenhall, as J. Legge and Company.

Cardiff Foundry and Engineering Company, Limited.—Capital £5,000 in £1 shares, to take over the business carried on in Cardiff by E. Curran and F. H. Turnbull, as the Cardiff Foundry Company. The first directors are E. Curran and F. H. Turnbull.

Arthur Ellis & Company, Limited.—Capital £2,000 in £1 shares (1,000 preferred), to carry on the business of general, mechanical and electrical engineers, etc. The first directors are A. T. Ellis and W. L. Heald. Registered office: 201, Caxton House, Westminster, London, S.W.

R. T. Heyes & Company, Limited.—Capital £1,400 in £1 shares, to acquire the engineering business of R. T. Heyes & Company, Oil Street, Liverpool. The first directors are R. D. Heyes, J. J. Heyes, G. F. Heyes, and L. F. Heyes. Registered office:—22, Oil Street, Liverpool.

Goodwin & Company, Limited.—Capital £12,500 in £1 shares (2,500 10 per cent. preferred), to take over the business of a steel merchant and manufacturer, carried on by Mr. S. C. Goodwin at the Scottish Steel and File Works, Neepsend, Sheffield, as Goodwin & Company. The first directors are Mr. Goodwin and Mr. A. Teather.

Stein & Atkinson, Limited.—Capital £4,000 in £1 shares, to carry on the business of makers of and dealers in furnaces, ovens, etc. The first directors are C. M. Stein (permanent governing director and chairman), J. S. Atkinson (permanent director and general manager), and E. P. Chaude. Registered office: 47, Victoria Street, Westminster, S.W.

Munroe & Gordon, Limited.—Capital £20,000, in 19,900 preference shares of £1 each, and 2,000 management shares of 1s each, to carry on the business of ironfounders, etc. The first directors are R. J. L. Fytche (chairman), J. M. Munroe (consulting engineer), E. J. Gordon (managing director), J. M. Alderton, and A. O. P. Gordon (all permanent).

Sabine Brothers, Limited.—Capital £5,000 in £1 shares, to take over the business of ironfounders and machinists carried on by A. E. Sabine and B. J. Allen, at the Vulcan Foundry, Belmont Street, Swadlincote, Derby, as Sabine Brothers. The first directors are A. E. Sabine (managing director) and Mrs. B. J. Allen (both permanent). Secretary, A. G Lambert.

William Ward & Son (Sheffield), Limited.—Capital £2,000 in £1 shares, to take over the business carried on at the Surrey Works, Broadfield, Sheffield, by J. Ward, as Wm. Ward & Son, mechanical electricians, constructional, motor and general engineers, etc. The first directors are J. Ward (permanent managing-director), C. Ward, S. Ward, and C. Ward. Secretary, Clement Ward. Registered office: Surrey Works, 182, Broadfield Road, Sheffield.

Legal.

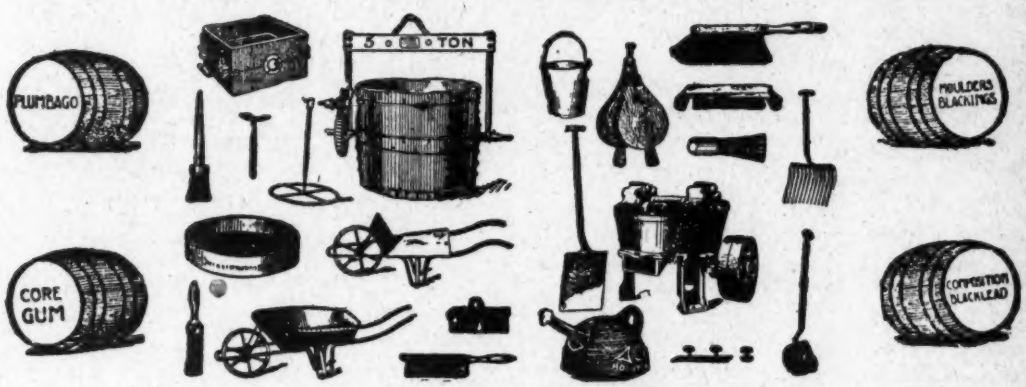
Monometer Furnace Action.

Mr. Muir Mackenzie, one of the High Court Official Referees, gave judgment, on July 3, in an action in which the Monometer Manufacturing Company claimed from the Electric and Ordnance Accessories Company, Limited, Ward End, Birmingham, the balance of contract price for supplying Monometer furnaces, etc. The case was reported briefly in our last issue. The Official Referee, in giving judgment, said there were two questions for consideration—first, what were the obligations of the plaintiffs, and secondly did they fulfil their obligations. The defendants wanted some large furnaces with a melting capacity of 1,000 lbs. aluminium, and some smaller ones with a melting capacity of 140-150 lbs. Attracted by the plaintiffs' advertisement of a new furnace, they approached the plaintiffs, and after full investigation entered into a contract with them to supply the required furnaces. The defendants contended that it was part of the contract obligations of the plaintiffs, first, that the furnaces should be capable of securing a certain weekly output; and, secondly, that the smaller furnaces should produce castings which were free from flaws and defects, and that they should be fit for melting aluminium with copper. It was clear that, notwithstanding the written contract, the additional obligation contended for could have been made binding upon the plaintiffs by verbal undertakings. The plaintiffs undoubtedly knew that the furnaces were required for turning out quickly castings for fuses, and that the metal would contain a mixture of zinc, but he could not find that the plaintiffs entered into any obligation with respect to the furnaces beyond the contract, and the question was whether the plaintiffs had made default in regard to those obligations. One cause of complaint was that the large furnaces did not provide sufficient output to feed the smaller furnaces, and that the iron pots were defective. As regards the large furnaces, the complaint was that the defendants did not get the quantity of molten metal required, but plaintiffs had not entered into any legal obligation that they should do so. The main cause of trouble in the smaller furnaces was due to the mixture of other metals with the aluminium. The plaintiffs did not undertake that their iron pots would not be subject to damage by alloys other than those specified being melted in them. He found against the defendants on the main issues. The plaintiffs were not in default. The plaintiffs' claim included a large sum for extra work done, and the defendants admitted that they ordered part of the work. As regards nearly all the items claimed for, however, he decided in favour of the defendants, who were not liable for additional work unless it had been ordered by them. The person who had contracted to have things done for a certain sum was entitled to resist all claims outside his contract. He decided that the extra items, which in the aggregate amounted to £548, should be struck out, and there would be judgment for the plaintiffs for £1,723 10s. 3d. on the claim, while defendants' counter-claim would be dismissed.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



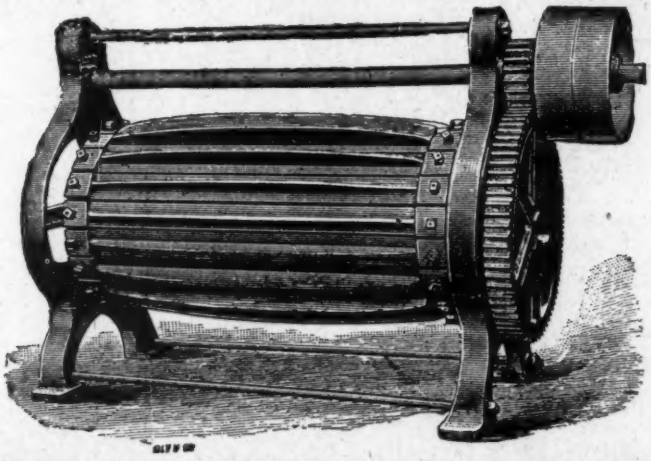
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

These maximum prices of iron, steel and coke were fixed by the Government until June 30, 1916, and thereafter until further notice. Makers may sell for delivery after June 30, on the understanding that the fixed maximum prices ruling on the 1st day of any month during the period of the contract will apply to all deliveries made during that month. This intimation must not be taken to authorise any sale or purchase or other dealing prohibited under the Defence of the Realm Regulations.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos., 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1. 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Lincolnshire, basic or foundry ..	4	12	6
Cleveland, No. 1	4	11	6
„ other grades	4	7	6
Northamptonshire, forge	4	7	6
„ foundry numbers	4	10	0
Derbyshire, forge	4	10	0
„ foundry numbers ..	4	12	6
Leicestershire & Notts., forge ..	4	10	0
„ „ foundry nos.	4	12	6
North Staffs, forge	4	10	0
„ „ foundry	4	12	6
„ „ basic	4	15	0
South Staffordshire—			
Part mine forge	4	15	0
„ foundry	4	17	6
Common Staffordshire ..	4	10	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	2	6
Cold blast	9	2	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1¼%

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows :—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Usual trade extras for special sizes, etc. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows :—

Millings and Turnings	5d	
Bar Ends	6d	

Both per lb. net delivered steel makers works

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	38	0	0
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	36	0	0
Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	34	0	0
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	120	0	0
Ferro-vanadium : 33/40% Va., per lb. of Va. contained in the alloy	0	15	0
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton	28	10	0
Ferro-titanium : 23/25%, per lb. carbonless..	0	1	5
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained ..	0	16	0
Ferro-phosphorus : 20/25%. Per ton	16	10	0
Ferro-tungsten : 75% to 80% per lb. of metallic tungsten contained	0	6	1
*Ferro-manganese 80%	25	0	0
„ export 30 0 0—40	0	0	

* F.o.b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	..105	0	0	106	0	0
Three months	.. 99	0	0	100	0	0
Electrolytic ..	..125	0	0	121	0	0
Tough ..	..114	0	0	118	0	0
Best selected ..	..116	0	0	120	0	0

Tin.

Standard, Cash	..165	15	0	166	0	0
„ Three months	166	10	0	166	15	0
English Ingots ..	—			170	0	0
Bars	—			171	0	0
Refined ..	..173	0	0	174	0	0

Spelter.

American ..	..	61	0	0	—	
Specials..	..	..	—			
Hard ..	..	50	0	0	52	0	0
British ..	..	—			62	0	0

Lead.

Soft Foreign ..	..	—			28	0	0
English ..	..	—			29	0	0

Antimony.

Regulus ..	..	—			95	0	0

Aluminium.

Virgin Metal 98/99% per ton	155	0	0	200	0	0

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II.	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—

CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
„ Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. 35/- above price of best selected copper.

15 per cent. Phosphor Copper .. 40/- above price B.S.

Phosphor Tin (5 per cent.) .. £23 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM).

***Chromium (Metallic).**

98/99% purity, per lb.	—	0	5	9

***Nickel.**

In cubes, 98/99% purity Per ton	220	0	0	

Nickel Silver.

	per lb.
Ingots for raising ..	..2/0 to 1/6
Ingots for Spoons and Forks	..2/0 to 1/5½
„ rolled to spoon size	..2/1½ to 1/7

***Tungsten Metal Powder.**

96/98% purity.. per lb. ..	0	6	3	

***Molybdenum Metal.**

96/98% purity.. per lb. ..	—

***Cobalt Metal.**

97% purity .. per lb. ..	0	7	6	

Quicksilver.

75 lb. bottle	17	13	9	

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	£	s.	d.
Steel scrap, heavy melting..	110	0		—	
Iron scrap cast (cupola metal)	75	0		80	0

London (f.o.b.).

Heavy steel	85	0	
Light „	45	0	
Heavy cast	80	0	

Control Prices.

Heavy Steel Melting Scrap ..	5	10	0
Turnings and Borings	2	15	0

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations :—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap	..118	0	0
Hy. Selected Scrap Brass ..	70	0	0
Hy. Tinned Copper Wire ..	..100	0	0
Best Selected Gunmetal Scrap ..	88	0	0

Re-melted Ingot Lead 20s. under English Lead price on date of order.

Stocks.

Metals.

	Tons.
Copper, Europe and afloat	11,640
Tin, London, Holland, U.S.A. and afloat	21,460

Coke.

Middlesbrough.

	s.	d.	s	d.
Gas Coke	30	0	32	6

Glasgow.

Foundry Coke	39	0	42	0
Furnace Coke	36	6	—	
Gas Coke	—		—	

London.

Welsh or Durham Foundry, d/d London Stations in truck	45	6	53	0
Ditto, d/d Birmingham Stations	44	0	48	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6	—	

CONTROL PRICES OF COKE.

	s	d.
Durham and Northumberland blast furnace	28	0
„ foundry	30	6
South Yorkshire, West Yorkshire, Lancashire, and Midland Counties blast furnace	25	8
South Wales blast furnace ..	30	0

All per ton net. f.o.t. ovens.

SITUATIONS VACANT AND WANTED.

POSITION Wanted, as Foreman or Assistant, by Moulder (age 30); well up in all foundry subjects; good practical training; excellent knowledge of metallurgy, etc. Good reference as to character and ability. —Address, Box 822, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.

FOREMAN Pattern Maker or Shop Superintendent seeks position with larger opportunity, where the services of a capable organiser and disciplinarian with wide experience in varied lines can be utilized.—Apply Box 824, Offices of *Foundry Trade Journal*, 165, Strand, London, W.C.

WANTED, for Factory near London, several First class Draughtsmen, thoroughly accustomed to the design of heavy motor road vehicles (petrol).—Apply, stating age, experience and salary required, to nearest Labour Exchange, mentioning No. A. 1971.—Application from men at present employed on Government work will not be entertained.

MOULDERS (Aluminium) required for immediate Government work. Experienced men used to high-class petrol motor work. Good wages and prospects, War bonus and overtime. No man on Government work may be engaged.—Write or apply in first instance to your nearest Board of Trade Labour Exchange, mentioning this paper, and No. A. 2015.

FOR SALE AND WANTED.

FOUNDRY TRADE JOURNAL, 90 monthly numbers, also 8 British Foundrymen's Association Year Books, for disposal. Best offer.—Apply, A. HARDWICK, 44, Claremont St. Holmes, Rotherham.

FOR SALE, One New 3 in. Root's BLOWER. One 4 in. ditto.
Two 5 in. ditto. All with ring oiling bearings, fast and loose pulleys. For immediate disposal.
H. J. H. KING & Co., LTD., Engineers, Nailsworth, Glos.

5-TON Hand Swing Foundry Jib Crane, racking in and out motion, top and bottom fixing footstep, chain tested to 5½ tons.—C. F. DAVIS, 18, Billiter Buildings, London, E.C.

ENGINEERING Works for Sale in the Midlands. Railway into Works. Orders in progress £30,000. Firm has developed an important speciality in large demand, showing continual and increasing sale.—Address, S. G., care of J. W. VICKERS & Co., LTD., 5, Nicholas Lane, E.C.

FOR SALE AND WANTED.—(*Continued.*)

ONE good Second-hand No. 2 Roots' Blower, belt-driven both ends, about 12in. pulleys, good gearing, 8 in. diameter outlet underneath, wooden vanes, ready for prompt delivery.—MARPLE & GILLOTT, LIMITED, Sheffield.

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply, HALL, 26, Paradise Square, Sheffield.

REFINED ALUMINIUM INGOTS

NOTCHED BARS.

SPECIFICATIONS GUARANTEED.

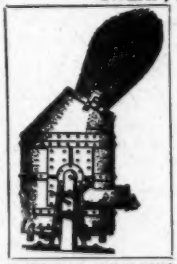
MIDLAND METAL CO., COVENTRY

PATTERN SHOP SUPPLIES.

Wires: "Requisites, Birm." **J. BURN & CO.,** 'Phone: 137 Victoria.

Henshaw Road, Small Heath, BIRMINGHAM.

ARE YOU INTERESTED IN THE PRODUCTION OF CHEAP, ACCURATE CASTINGS?



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FOUNDRY MATERIALS AND REQUISITES.

Largest Stock of Straw and Wood Fibre CORE ROPINGS.

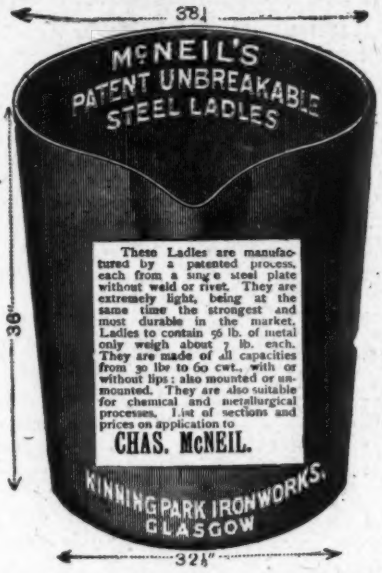
Wax Core Vent.

GLUTRIN—CORE GUM.

FIRE BRICKS & CLAY
CUPOLA BRICKS.
Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

KING BROTHERS,
(STOURBRIDGE) Ltd.,
STOURBRIDGE.

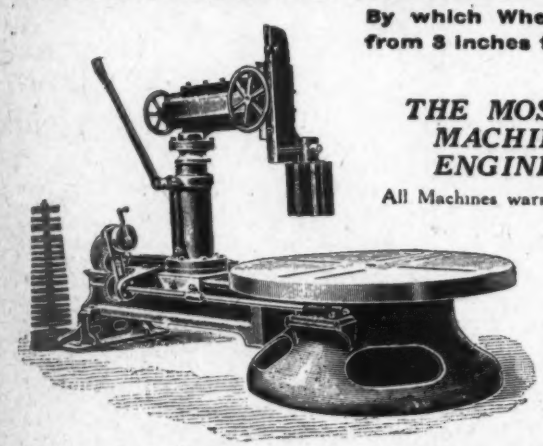

38½
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lbs to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW
30"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, *OLDHAM.*

Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

PAGE.	NAME.	ADDRESS.	TELEGRAPHIC ADDRESS.	TELEPHONE NO.
503	Adaptable Moulding Machine Co.	Stanhope Street, Birmingham	"Adaptable"	1966 Mid.
452	Alldays & Onions, Ltd.	Birmingham	Alldays, Birmingham	28 Victoria
450	Anglo-Mexican Petroleum Products Co., Ltd.	Finsbury Court, Finsbury Pavement, E.C.	Mexproduct, Ave, London	City 2704
459	Braby, F. & Co., Ltd.	Petershill Road, Glasgow	Braby, Glasgow	—
C. iii.	Bradley, T. & I. & Sons, Ltd.	Darlaston	Bradley, Darlaston	—
458	Britannia Foundry Co.	Coventry	Stoves, Coventry	251
454	British Binderit Co., Ltd.	Wharf Road, Wandsworth, S.W.	Bindercomp, Wands., London	994 Putney
C. ii.	British Thermit Co., Ltd.	49 & 51 The Albany, Liverpool.	Thermital, Liverpool	1680 Central
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C. iv.	Buckley & Taylor, Ltd.	Castle Iron Works, Oldham	Engines, Oldham	Oldham No. 8
503	Burn, J. & Co.	Small Heath, Birmingham	"Requisites," Birmingham	137 Victoria
503	Corebind, Ltd.	5, Castle Street, Finsbury, London, E.C.	"Corebind," Castle St., Finsbury	9029 Wall
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451	Davies, T. & Son	West Gorton, Manchester	Tuyere, Manchester	70 Openshaw
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462 & 497	Evans, J. & Co.	Manchester	Ladles, Manchester	2297
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458	Fyfe, J. B., & Co.	Shipley, Yorks	Brick, Shipley	59 Shipley
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450	Goldendale Iron Co., Ltd.	Tunstall, Stoke-on-Trent	Goldendale, Tunstall, Staffs	—
460	Gray, Thomas E. & Co.	3—4, Lincoln's Inn Fields, Kingsway, London, W.C.	Papplewick, Holb, London	1946 Holb.
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	Hislop, R. & G.	Paisley	Gas, Paisley	331 Paisley
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455	Keith, James & Blackman Co., Ltd.	27, Farringdon Avenue, London	James Keith, London	6194 H'lb'rn (4 lines)
504	King Bros. (Stourbridge), Ltd.	Stourbridge	King Bros., Stourbridge	—
499	Lowood, J. Grayson, & Co., Ltd.	Deepcar, nr. Sheffield	Lowood, nr. Sheffield	18 Stocksbridge
	Mansergh, T. E.	Wheathill Charcoal Works, Salford	—	—
	Marshall, H. P. & Co.	Leeds	Speciality, Leeds	1909 Leeds
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504	McNeil, Chas.	Kinning Park, Glasgow	McNeil, Glasgow	X 155
503	Midland Metal Co.	Coventry	—	—
449	Monometer Manufacturing Co., Ltd.,	125, Whitehouse St., Aston, Birmingham	—	—
453	Naish & Croft	150, Alma Street, Birmingham	—	—
504	Olsen, William	Cogan Street, Hull	Wm. Olsen, Hull	Nat. 1184
C. iii.	Phillips, J. W. & C. J.	23, College Hill, E.C.	Colloquial, London	10112 Central
499	Portway, Chas. & Son	Halstead, Essex	Portway, Halstead	10 Halstead
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460	Universal Machinery Corporation, Ltd.	326, Old Street, London, E.C.	Toolcraft, London	3763 London Wall.
453	Walker, I. & I.	Rotherham	—	—
	Walco, Ltd.	53, Newton Street, Birmingham	Walco, Birmingham	Central 3305
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453	Williams, J. (Birmingham Sand), Ltd.	Birmingham	—	—

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ABSOLUTELY UNAPPROACHABLE.

The **Monometer Pit Type Crucible Furnace (Hall's Patent)** is suitable for reducing **brass, copper, nickel alloys, gunmetal, Admiralty metal, Delta Metal, etc., brass, aluminium and other turnings,** and is made for **gas, oil or coke firing. Output.** The Monometer **Patent Burner** system produces an intense heat with a minimum consumption of fuel resulting in **a quicker reduction** than with any other system. *No other furnace can compare with the Monometer.*

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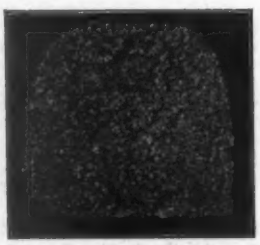
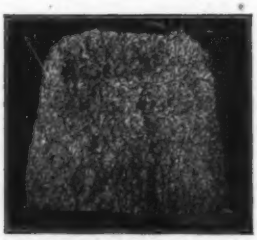
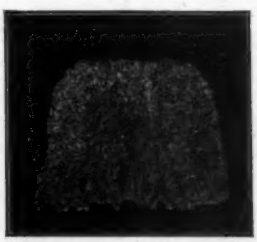

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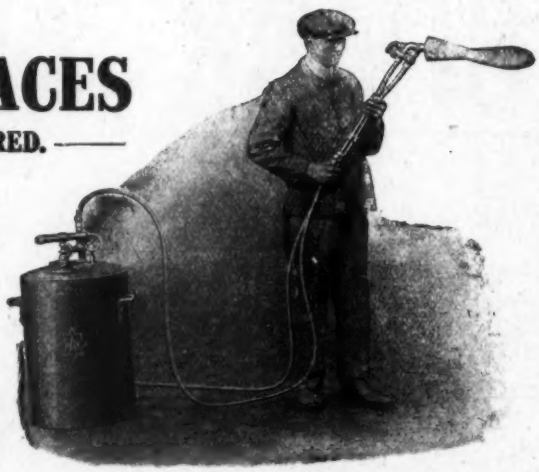

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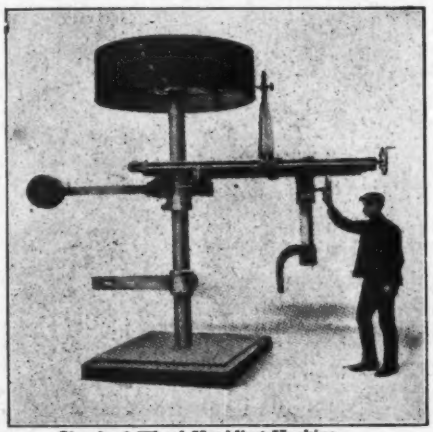

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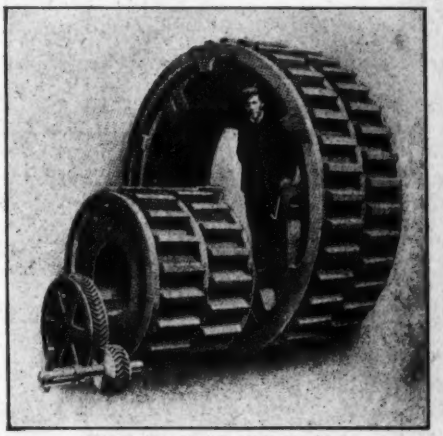

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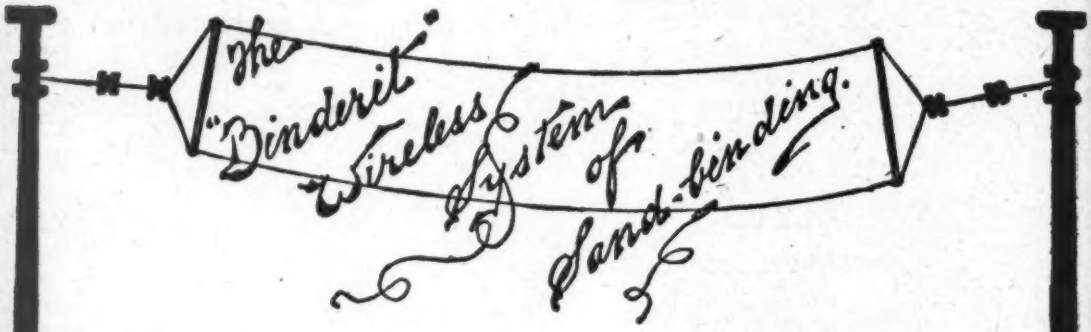

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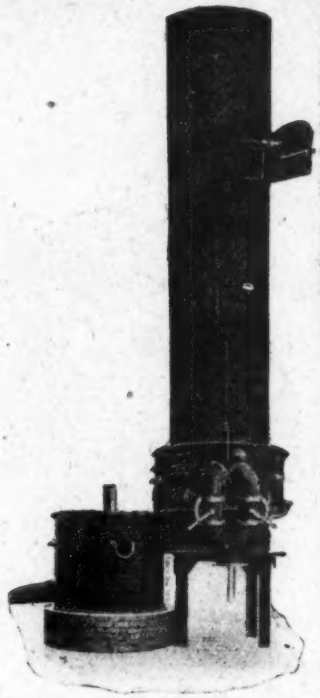

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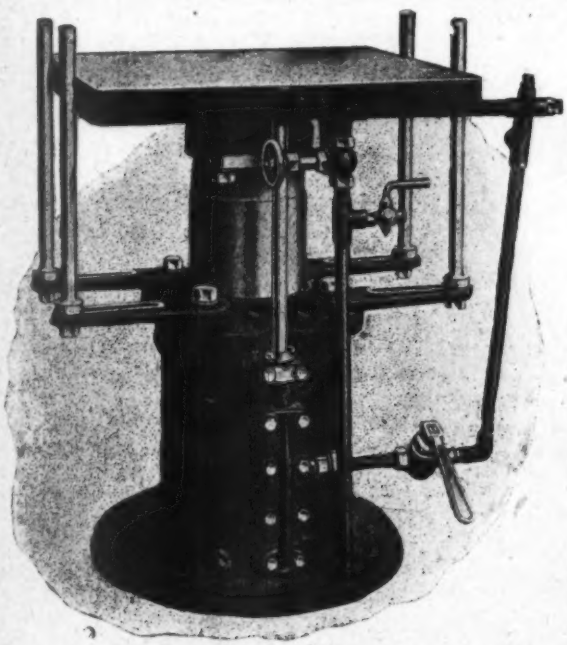

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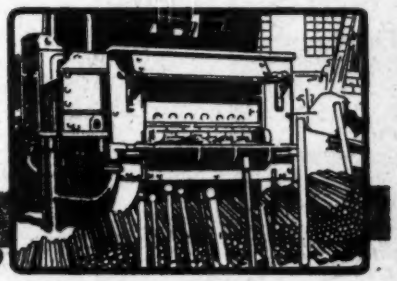

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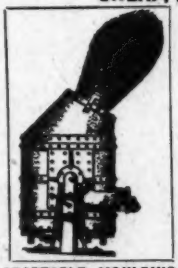

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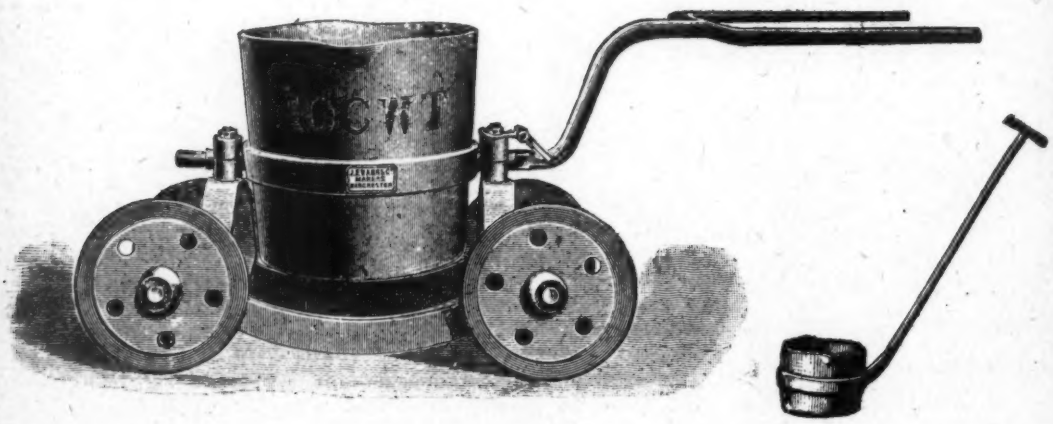

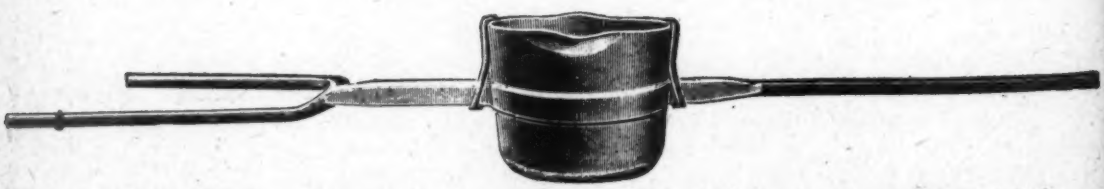

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